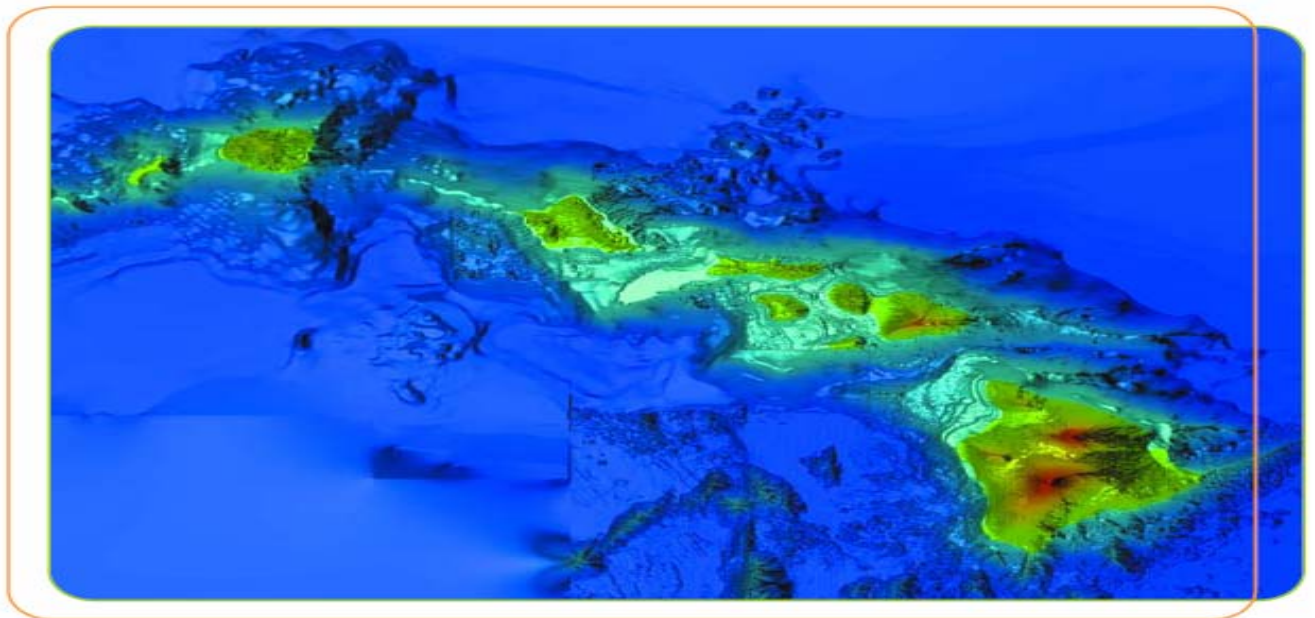


Hawaii's Life Sciences Road Map: Competitive Opportunities in the Global Economy



HAWAII
LIFE SCIENCES
COUNCIL

**A Report to Stakeholders
July 2005**

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1 – Conveyance of Road Map and Acknowledgements

June 2, 2005

Memorandum to Executive Committee, Hawaii Life Science Council
From Richard Seline, CEO and Principal, New Economy Strategies, LLC
Re Conveyance of Road Map and Acknowledgements

Please find attached the 2004-2005 *Hawaii Life Science Innovation Road Map* based on the engagement of nearly 300 Hawaii stakeholders in the creation of a competitive scenario and positioning as a global hub in human, plant and medical information-related sectors.

The citizens of Hawaii will find herein the counsel and guidance from the best minds and experts across disciplines and geography, making the Road Map truly larger than any one organization or institution, either in the academic or industry arenas. We encourage the readers of the Road Map to consider an important environment for the construct and implementation of the plans outlined throughout this document:

- The State of Hawaii has benefited from the important federal, military and industry investments in unique assets tied to the current and emerging technologies of life sciences – from the Maui Supercomputer to the Tripler Army Medical Center, from the UH’s new JABSOM Medical Campus to the global seed industry locations throughout the Islands
- As life sciences becomes more globally-oriented, the population and genetic information found in Hawaii links the U.S. to the importance of a Pan-Pacific partnership around emerging infectious diseases, individualized pharmacogenomics, and clinical trials
- At no time in the past has the barrier of location become less important to the discovery-development-delivery of new treatments. Simply, the perceived remoteness of Hawaii has been lessened by access to best-in-class digital, wireless, and satellite resources to both connect and leverage telemedicine, bioinformatics, and appropriate research collaboration on either side of the Pacific
- The recognition that plant-sourced knowledge and experience in Hawaii offers long-term economic and health benefits to local populations as well as global markets interested in food safety, nutraceuticals, and the ‘Hawaiian’ cultural respect for the land.

Hawaii is blessed by its sense of place and people to co-exist in a period of accelerated scientific and technological discovery and development. This balance of culture, science, technical aptitude and economic opportunity for all citizens reflects the “Healing Islands” concept that has emerged during the Road Map process. By bridging the east and the west in medicine, health care, ethics and quality of life, Hawaii is poised as a global hub for Life Science Stewardship. What remains is the design and implementation of organizational mechanisms to convert public investments into economic and societal benefit that honor this 21st century form of civic stewardship.

The term ‘stewards’ refers to the civic, business, and political leaders who are collaborating to complete the tasks under the umbrella of the Road Map. Such leadership requires a public commitment, accountability, and on-going performance measurement of progress towards key milestones. In other words, the stewards assume the responsibility of “holding feet to the fire” for execution, follow-through, and completion of the Hot Team business plans.

The SWOT analysis, the frank assessment and the identification of critical priorities should be considered as positives which build upon the work of previous groups and organizations.

This report would not have been possible without the significant contributions of many dedicated individuals and institutions; the contributors to this report were too numerous to mention by name. We would especially like to thank the leadership of and team members at Enterprise Honolulu, whom sparked the initial discussions around a life science assessment by an external firm so as to provide a perspective of both reality and possibility for the future of Hawaii in a complex and competitive economic sector. In turn, the leadership and resources offered by The Kamehameha Schools has played a critical role in facilitating the Road Map process from beginning to end. The Project Advisory Group’s contribution by providing NES access to the voices, information, and institutional history of Hawaii has been overwhelming in both depth and breadth. The evolution of a statewide civic and industry organization – the Hawaii Life Science Council – is both a by-product and consequence of engaged leadership seeking the platform on which to complete and implement the Road Map – and therefore the executive committee of the Council is recognized for its pledge and promise as the initial stewards and implementers of the Road Map.

Most importantly, our very special thanks go to the co-chairs, shepherds, and members of the Hot Teams, as well as the Innovation Road Map survey and interview participants. These nearly 300 individuals have are the real ‘architects and engineers’ of the Hawaii Life Science Innovation Road Map!

2 - Project and Report Overview

Background:

While Hawaii has conducted several studies, reports, and previous data-collection on its knowledge-based sciences and innovation capacities, little of that new knowledge has found a mechanism for on-going implementation and effective utilization among several stakeholders and end-users. Disparate sources of knowledge and data-collection are just now coming together around an efficient methodology for building the regional life science cluster and day-to-day responses to important challenges to reaching a globally competitive strength. By knowing and connecting resources within and beyond the region about who is doing what, where, on which capacities and resources, Hawaii will be able to use its resources more effectively and efficiently. It is through networks of social interaction – social capital and proximity – that will foster the real ecosystem that benefits both the hard science and the supportive infrastructure. With the planning underway for the Kakaako lands and discussions about accelerating the role of the University of Hawaii components, there is no better time to connect and leverage the people and institutions of Hawaii into a physical and digital network of knowledge as both a branding and an operating model.

The Hawaii Life Science Innovation Road Map:

To facilitate the process of understanding Hawaii's life science assets and opportunities, the Hawaii Life Sciences Council (HLSC), with financial support from KS and in partnership with Enterprise Honolulu, engaged New Economy Strategies (NES), a Washington, DC based consultancy, to develop a comprehensive roadmap that provides strategic guidance to the state's life science initiative. Joining the HLSC, EH and KS in supporting the *Life Science Innovation Road Map* initiative are the University of Hawaii System and the Department of Business-Economic Development-Tourism.

The purposes and outcomes from the project seek to ensure excellent health care Hawaii residents, family wage jobs, creation of new career opportunities and enterprises. To do so the *Life Science Innovation Road Map* focused on achieving three objectives:

- Identify the Islands' life science and innovation assets;
- Galvanize the statewide leadership needed to catalyze growth in targeted life science cluster activities; and
- Make long- and short-term recommendations for achieving national and international competitiveness in a handful of targets of opportunity.

NES worked with regional and state leaders to research Hawaii's capacities to compete, innovate, and perform around current and emerging biotechnology and related technology clusters. The focus was on creating economic 'churn' through innovation.

Churn: Sustainable, consistent adaptation and evolution over the course of the business stages of the Innovation Lifecycle® (conception, formation, growth and maturity). Churn is the ability of a region's economic, scientific, technological and entrepreneurial resources to continually and collaboratively produce new ideas and new enterprises.

Innovation: A continuous social process of discovery and invention that brings together and aligns a variety of institutions, industries, and individuals to create new products, services, and ultimately new ways of competing in the global marketplace.

Key elements of the *Hawaii Life Science Innovation Road Map* process included the following:

- Collect and analyze data that build the business case and value proposition for the Targets of Opportunity;
- Benchmark new approaches and focused technology trends;
- Interview and survey key business, academic, government leaders and other critical stakeholders
- Conduct eight 'talk story' sessions with 65 regional leaders to present preliminary findings, identifying priorities, determining critical focus areas, and establishing the willingness to collaborate across sectors;
- Identify target areas of opportunity in existing science and technology competencies, emerging sectors, and traditional industries;
- Determine overarching tactics focused on cluster-specific needs (e.g., skills training, new enterprise development, technical requirements) and cross-cluster issues (e.g., infrastructure, capital formation, workforce development);
- Form 'Hot Teams' comprised of academic, industry, government, and other state and regional stakeholders to craft very specific initiatives and related business plans to address each target of opportunity.

Key Players in the *Innovation Road Map* process included the following:

- **Sponsoring Organization: The Hawaii Life Science Council (HLSC):** Established to promote life science-oriented technology based economic development, HLSC promotes the development and commercialization of biotechnology, pharmaceutical, medical device, health information and other technologies through a statewide network. HLSC leveraged its expertise and resources to assist Enterprise Honolulu in linking the Innovation Road Map within the Hawaii Statewide Comprehensive Economic Development Strategy (CEDS). HLSC managed the Hawaii Life Science Innovation Road Map process on behalf of Kamehameha Schools (the lead funding organization for the project).
- **Supporting Organization: Enterprise Honolulu** is a not-for-profit organization serving as a unified voice promoting and representing the technology-based interests, larger economic development community in Hawaii.

- Supporting Organization and Leading Funding Entity: **The Kamehameha Schools (KS)** plays a critical role in ensuring its students' entry into the workforce by having the necessary educational attainment at the high school and college levels.
- Supporting Organization: **the University of Hawaii** has contributed extensive time and energies to the Innovation Road Map process through the Office of the President (David McClain) and the leadership resources of Jim Gaines (Vice President for Institutional Development). The support of the RCUH under the guidance of Mike Hamnett has fostered discussion in the Hot Teams on business incubation services, pre-seed capital and technology transfer support activities for individual entrepreneurs in the region and to commercialize intellectual property emanating from basic research at the University.
- Strategic Advisor & Consulting Organization: **New Economy Strategies (NES)** is a national consulting firm based in Washington, D.C. with a proven track record for developing and implementing technology-based economic development strategies. NES was engaged by Enterprise Honolulu, Kamehameha Schools, and the Hawaii Life Science Council to develop the *Hawaii Life Science Innovation Road Map*.

3 - Executive Summary and Recommendations

3.1 – Life Science Definition and Competitive Landscape

The complex construct of the life science community does not allow for an easy examination of its segments and applications, as they are often inter-related, overlapping and/or newly emerging. The increasing use of collaborative efforts among various entities along the supply and value chains as well as the convergence opportunities offered by the pervasive thread of technological advances makes the task a complicated one. Our definition of the life sciences seeks to include a broad platform of technological and scientific reach – including plant and animal production, medical devices, bioinformatics, and health care management.

Examples of the Life Science Industry:

Primary: Human, Plant, Marine, Industrial/Environmental, Health Care Delivery

Secondary: Pharmaceuticals, Plant-made Pharmaceuticals, Nutraceuticals, Plant Sciences, Agri-biotechnology, Bio-materials, Homeland Security, Environmental Remediation, Bio-fuels, Veterinary Medicine, Medical Devices, (Instruments, Supplies, and Diagnostic Equipment), Biotech Drugs, Therapeutics, Health Information technologies (Wireless, Sensor, Telemedicine).

General Competitive Landscape:

Hawaii faces competition not just from other US states and regions, but from across the globe. Advanced nations with long histories of scientific excellence such as England, France, and Germany are well-established global competitors. Additionally, serious competitive pressures are also being brought to bear by rising stars such as Brazil, Singapore, Taiwan, India, and China who are investing heavily in their human capital and innovation infrastructure.

The possibilities for growth in the new economy are virtually unlimited. Life science is such a vast, complex, and still largely uncharted frontier, that it is not possible for any one state, country or region to be the authoritative leader in all of its aspects. Any area in the world is free to develop its own niche expertise, based on the unique assets that it has and create. Therefore, if Hawaii has the vision, and is able to coordinate the resources, both internal and external, it can create the necessary critical mass of innovation and become a serious global contender. Potential competition, growth and diversification in the life sciences, the so-called “Bioeconomy” is also virtually unlimited.

Existing Innovation Expertise and Assets:

Hawaii is well-positioned to become a life science leader in specific areas, both due to its existing expertise in many of the various elements of the ‘bioeconomy’ (human health, animal and plant sciences, biomaterials, military/homeland security, and information and computer technology), and due to its existing assets (a skilled workforce, high quality research and education institutions, clusters of high technology companies, etc.). Table 1 highlights some important components of Hawaii’s innovation economy, as well as how Hawaii ranks nationally in those categories over the past four to five years.

Table 1 - Snapshot of Hawaii Innovation Economyⁱ

Indicators	Hawaii Totals	National Rank
Total Gross State Product, 2003 (millions of \$)	\$47,066	41
<i>Per Capita</i> Personal Income, 2003	\$30,913	21
S&E Doctorates Awarded, 2002	76	41
Population, 2003 (thousands)	1,258	43
Federal R&D Obligations, 2002 (millions of \$)	\$375	33
Total R&D Performances, 2002 (millions of \$)	\$456	43
Industry R&D, 2002 (millions of \$)	\$103	47
Academic R&D, 2002 (millions of \$)	\$173	38
% of Academic R&D Invested in Life Sciences	37%	NA
Academic R&D Invested in Life Sciences (millions of \$)	\$64	NA
Public Higher Education Current-Fund Expenditures, 2001 (millions of \$)	\$738	40
Number of SBIR Awards, 1999-2002	82	31

3.2 – Methodology and Approach

The data collection and the analysis of Hawaii’s life science competencies followed a three phase process (detailed in Figure 1 below). The three phases were 1.) Collecting data and mapping existing assets, 2.) Identifying opportunities on which to target time and efforts to design the Road Map, and 3.) Finding the means to launch a sustainable implementation effort driven by partnerships between academia, industry, and government.

Figure 1 - Three Phase Road Map Implementation Processⁱⁱ



3.3 – Summary of Qualitative and Quantitative Data

Table 2 briefly outlines the different pieces of quantitative and qualitative data collected during the Road Map process that helped drive the findings and recommendations.

Table 2 – Data Collection for the Hawaii Life Science and Innovation Road Map

Source	Description	Intended Outcome
Quantitative Data		
Competitive Benchmarking	Comprehensive market assessment / competitor analysis on a domestic and global scale of the trends for the various targets of opportunities	Identify strategies, tactics and approaches for implementation
Industry/ Workforce Analysis	Gather comprehensive data by specific bioscience industry and sector, including employment, wage and output data from Economy.com	Build the fundamentals of the regional clusters and determine the regional, national and global economic trends within key sectors impacting the current and future direction of Hawaii
RAND RaDiUS	Database that tracks all federal dollars awarded in science and technology to public and private entities	Identify research areas with current or potential for generating substantial federal support & funding as well as commercialization
Patent Research by 1790 Analytics, LLC	Provides unique access to academic papers and patents	Determine critical outcomes from research application and precursors of potential commercialization
MoneyTree Survey	The definitive source of information on emerging companies that receive financing and the venture capital firms that provide it	Provides venture capital investment activity, both for Hawaii and for the US, by high – tech industry, 1995 - 2003
Academic R&D and S&E Degree Production	Survey of Federal and overall academic R&D funding and educational resources in Hawaii and competitor states	Number of PhDs in science and engineering (S&E) and Academic R&D funding, particularly in Life Sciences. Per capita public higher education spending. Number of degree-granting institutions.
Qualitative Data		
Interviews and ‘Talk Story’ Discussions	Hawaii stakeholders and leaders participated in in-person and telephone-based 60 minute interviews, as well as 8 two-hour talk story sessions	Participants discussed and debated preliminary findings, generated feedback on initial recommendations, and prioritized future actions necessary for competitiveness
Regional Mindset Survey	Electronic survey distributed to more than 1,000 community and business leaders containing questions surrounding innovation, the economy, and perceptions about the region.	Acquire a set of key action steps and recommendations for accelerating the competitiveness of Hawaii and assess current attitudes about the state’s ability to compete

3.4 - Summary of Findings

The work of the Hot Teams complimented and focused the results of the quantitative and qualitative data gathered during the road map process. When all of the separate elements were brought together, a clear and compelling picture of Hawaii's assets and targeted opportunities began to emerge. Thanks in particular to the work of the Hot Teams and to the input gathered from the survey and interview participants, it was possible to identify a clearer view of Hawaii's primary strengths and weaknesses, as well as the opportunities and threats it faces in the future.

Strengths: The many underlying strengths inherent to Hawaii include a highly-educated and productive labor force, a high quality of life, strong educational institutions, and generations of expertise in key areas such as plant sciences, marine and environmental sciences, and information-telecommunications systems.

Opportunities: The most promising opportunities lie in areas where Hawaii can leverage existing competencies, such as in human health, agriculture, and information technology.

Weaknesses: Weaknesses include a lack of venture capital funding, inadequate levels of federal funding beyond the support of the Congressional delegation, and the lack of a coordinated pipeline to provide Hawaii's businesses with the workforce and knowledge workers of the future.

Threats: Threats facing Hawaii include human capital flight (*e.g.* "Brain Drain"), increased global competition, and the risk of being perceived negatively outside the state, or simply overlooked, in the absence of a coordinated branding and positioning effort.

3.5 – Hot Team Targets of Opportunity

Based on the quantitative and qualitative findings, six Targets of Opportunity (areas of high potential) were identified. Accordingly, six groups of industry, academic, and civic leaders were formed into Hot Teams to evaluate the existing assets and competencies in these areas, and to determine Hawaii's ability to exploit these opportunities to compete in the global marketplace. The Hot Teams were composed of individuals from diverse backgrounds united by their common commitment to finding solutions to the challenges facing Hawaii. The six Targets of Opportunity around which the Hot Teams were formed are outlined in Table 3.

Table 3 - Hot Team Target of Opportunity Profiles

Hot Team	Description
Beyond Brick & Mortar	While acknowledging the importance of real estate, available land, and Kakaako as “the” central location for the life sciences, Hawaii has unique opportunities in the soft infrastructure of people, skills, capital, and other innovation/creativity ingredients
Digital Medical Arts	Through the investments of NASA, National Science Foundation, and DOD, Hawaii has specific elements of communicating ideas and discoveries through creative applications of digital arts (graphics, broadband telecommunications, telemedicine, high-speed bioinformatics, etc.). Bioinformatics is the convergence of computer science, information technology and biotechnology. Telemedicine is the use of telecommunication to provide diagnostic and therapeutic medical information between a patient and doctor without either of them having to travel.
Environmental & Marine Sciences	Biomass, biofuels, biomaterials, and other environmental applications are a subset of myriad applications of advanced biological sciences research.
Integrated Health Discovery & Delivery	Drug discovery and development includes target discovery and identification, lead discovery and identification, drug metabolism and toxicity, drug process and development, and application of genomics, proteomics, pharmacogenomics and bioinformatics in accelerating drug discovery and development. How does Hawaii uniquely tie the discovery successes to the importance of health care delivery among hospitals, doctors offices, specialists, corporate human resources, insurance and third party payers?
Emerging and Persistent Diseases	The Pacific Rim is fast becoming a breeding ground for new forms of infectious disease including avian flu, West Nile virus, and other airborne related health challenges. At the same time, long-plaguing diseases from the Asian and Hawaiian populations (obesity, cardiovascular, hypertension, diabetes, etc.) are increasingly expensive to treat and easily prevented. Can Hawaii become the U.S. front line to combat, prevent, stop these new outbreaks?
Plant Sciences	Plant Science is the field of study involving the production, marketing, utilization and study of plants and plant materials; focus on the historical seed and crop related research and production in Hawaii

3.6 – Summary of Hot Team Recommendations

During the three month Hot Team process, the six groups discussed more than forty distinct ideas, and developed detailed business plans outlining the best of these proposals. Because of the considerable relationships and connections existing between the Hot Teams, it was possible to synthesize the key elements of the business plans into five “Big Ideas,” seven “Fundamental Actions,” and one overarching “Enabling Factor” (the “Statewide Collaboratory of Knowledge” for coordinating and collaborating information and action). Combining the plans into focused initiatives allows Hawaii to effectively leverage its resources and concentrate its strengths on the highest potential actions. It is worth noting that none of the “Big Ideas” or “Fundamental Actions” developed from the efforts of one single Hot Team, and each of the six Hot Teams made fundamental contributions to at least one of the “Big Ideas.” Rather, it was the strong cooperation between teams which allowed the relationships to develop. Table 4 below outlines the “Big Ideas” and the “Fundamental Actions,” and which Hot Teams contributed to which recommendations.

Table 4 - Hawaii Road Map Recommendations: Big Ideas and Fundamental Actions

	Cross-Cutting Initiative:	Hot Team Contributions
Big Ideas	1.) Pan-Pacific Infectious Disease Institute	- Drug Discovery - Health-related IT
	2.) Chronic Disease and Health Outcomes	- Integrated Health - Emerging Diseases
	3.) 21 st Century Digital Medical Arts	- Medical Arts - Emerging Diseases - Integrated Health
	4.) Hawaii Bioproducts Initiatives: Renewable Energy and Bio-fuels	- Plant Science - Biomass & Biofuels
Fundamental Actions	1.) The Statewide Workforce Continuum: <i>Developing Skills, Competencies and Future Talent</i>	All Hot Teams
	2.) Branding & Positioning: <i>Marketing Hawaii's Assets Globally</i>	All Hot Teams
	3.) Statewide Funding Team: <i>Gathering Resources for Competitiveness (Federal, State, Industry, Philanthropic \$\$s)</i>	All Hot Teams
	4.) The Hawaii Dialogue	All Hot Teams
Enabling Factors	Statewide Collaboratory: <i>Accelerating Life Science Connectivity through an Infoplex, High-Capacity Computing, and R&D Network for Clinical Trials and Commercialization</i>	- Health-related IT - Drug Discovery

Just as important to the collaboration among the Hot Teams was the role of applying specific performance metrics to “keep feet to the fire” on the next stages of implementation, and the designation of the Life Sciences Council as the catalyst mechanism for partnering with any and all institutions and organizations on each element of the business plans, to ensure implementation.

3.7 – Implementation Timeframe

Table 5 below outlines some of the most important next steps and milestones for the immediate-term, near-term, and long-term implementation of the “Big Ideas,” “Fundamental Actions,” and “Enabling Factor.” Respondents to the survey and participants in the Talk Story sessions and Hot Teams indicated a desire to implement rather than study, execute on plans rather than revise and polish to perfection.

The timeline constructed from the Hot Team process provides for a three year window and relies upon a number of organizations, institutions, and individuals to commit time and resources towards the successful completion of each task. Through the over 130 interviews conducted for the Road Map, a majority of participants identified one of Hawaii’s challenges as “the willingness to complete tasks upon launch any new program or project.”

Table 5 - Hot Team Implementation Timeline

Immediate (0-18 months)	Near-term (18-36 months)	Long-term (36+ months)
Big Idea #1: Pan-Pacific Infectious Disease Institute		
Inventory assets along disease categories. Partnering within the Institute.	Identify and recruit global partners. Identification of priorities for test-bed, pilots (e.g. Gates Foundation, WHO)	Production, spin-off, commercialization of new product. 100% utilization rate by service providers, end-users, deployment
Big Idea #2: Chronic Disease and Health Outcomes		
Encourage greater collaboration across multiple institutions and geographic interests. Partnering within the Fusion Center.	Launch Center sub-category programs; identification of priorities for test-bed, pilots. (e.g. digital demographic pathology laboratory)	Statewide adoption and utilization of the services and programs offered through the comprehensive cancer center.
Big Idea #3: 21st Century Digital Medical Arts		
Attention to 2-3 specific products, markets (e.g. virtual medical diagnostics)	Creation of product development 'teams'	Recognition as the location for innovation, creative materials
Big Idea #4: Hawaii Bioproducts Initiatives: Renewable Energy & Bio-fuels		
Establish prioritized agenda of market analysis, targets. Form Biofuels Working Group and Neutraceuticals Working Group	Launch Biofuels Investment Corporation to create collection-conversion-delivery fuels system	Reduction of oil-based energy supplies by 25% from converted biofuels.
Fundamental Action #1: The Statewide Workforce Continuum		
Organize Continuum 'Hot Team' among key providers	Match occupation training and skills for the initial 1000 positions	Successful realignment of education, training, provider, and end-user networks
Fundamental Action #2: Branding and Positioning Campaign		
Coordinate Road Map data with statewide message campaign	Target 10-12 top communications' outlets for external messaging	Increase inward investment to Hawaii by 20% and recognition of the State role among site selectors, economic developers
Fundamental Action #3: Statewide Funding Team		
Inventory of top priorities from among above agenda	Funding Team and Campaign launched	Promote Hawaii moving from EPSCOR to New Ranking
Fundamental Action #4: The Hawaii Dialogue		
Implementation of legislative agenda for the commercialization focus	Attraction of industry and entrepreneurial risk-taking new dollars, skills	Completion of \$100 million in startup, growth and mature stages of investment
Enabling Factor: Statewide Collaboratory		
Make permanent the electronic infrastructure created from the Hot Team process. Devise mechanism to encourage principal investigators to share knowledge, incentivize cooperation.	Develop structure and methodology for matching grant management/co-investments, secure funding. Assist with branding and positioning efforts.	Facilitate the formation of lasting partnerships between industry, principal investigators, academia, and government. Position the collaboratory as a clearinghouse for research and intellectual property.

4 – Hawaii Bioscience Snapshot and Competitive Position

4.1 - Bioscience Definition

Though the bio- and life sciences are often perceived to primarily comprise pharmaceutical drug development and medical devices, NES takes the position that the larger the definition the more inclusive the range of potential activities. This sample list of North American Industrial Classifications (Table 6 below) identifies the multitude of opportunities in some of the human, plant and animal areas.

Table 6 - NAICS Codes Examined

NAICS Code	NAICS Title
325411	Medicinal and Botanical Manufacturing
325412	Pharmaceutical Preparation Manufacturing
325413	In-Vitro Diagnostic Substance Manufacturing
325414	Biological Product (except Diagnostic) Manufacturing
325193	Ethyl Alcohol Manufacturing
325199	All Other Basic Organic Chemical Manufacturing
325311	Nitrogenous Fertilizer Manufacturing
325320	Pesticide and Other Agricultural Chemical Manufacturing
334516	Analytical Laboratory Instrument Manufacturing
339111	Laboratory Apparatus and Furniture Manufacturing
339112	Surgical and Medical Instrument Manufacturing
339113	Surgical Appliance and Supplies Manufacturing
334510	Electromedical and Electrotherapeutic Apparatus Manufacturing
334517	Irradiation Apparatus Manufacturing
339115	Ophthalmic Goods Manufacturing
621511	Medical Laboratories
621512	Diagnostic Imaging Centers
541710	Research and Development in the Physical, Engineering, and Life Sciences
541380	Testing Laboratories
541940	Veterinary Services
622110	General Medical and Surgical Hospitals

Behind the classification codes of the life science sub-sectors are myriad companies, firms, enterprises and occupations. The composition of a life science cluster – and the breadth by which the cluster is inclusive indicates the potential opportunities for vital collaboration, partnerships, and alliances around infrastructure, workforce, intellectual property management, and the like. To create the ‘snapshot’ of the cluster – a point in time for which we can precisely measure the current economic, scientific, and entrepreneurial activities, NES relies on several sources of hard, quantitative data and information backed by insights, anecdotes and counsel of industry and academic representatives.

4.2 – Hawaii Life Science Snapshot

Important to note when examining the Hawaii life sciences is the count of establishments and wages that define the reach and composition of the sub-cluster industry relative to overall, general employment. Of consequence for Hawaii is that none of the top five common employment areas (services, tourism, retail, etc.) has an higher annual wage that matches the lowest wage found in just four of the life science related occupations and sectors. Simply, contrasting Table 7 with other charts throughout this report will confirm that Hawaii's knowledge-based, technology-driven economy will improve the economic fortunes of the State and its residents for the foreseeable future.

Table 7 - Hawaii Bioscience Snapshot: Establishments, Employment, & Wages, 2002ⁱⁱⁱ

Industry Sub sector →	Agricultural Feedstock & Chemicals		Drugs & Pharmaceuticals		Medical Devices & Equipment		Research & Testing		
	↓ Metric ↓	HI	US	HI	US	HI	US	HI	US
2002 Establishments		17	3,353	6	2,536	8	6,120	34	5,149
2001 - 2002 Establishment % Change		14.0%	-0.9%	0.0%	0.7%	-11.8%	-0.1%	-4.0%	-2.0%
2002 Employment		294	156,759	87	293,179	120	326,201	385	116,733
2001 - 2002 Employment % Change		-16.8%	-5.6%	7.4%	4.5%	-59.8%	-1.3%	-5.7%	0.1%
Share of US Employment		0.2%	100%	0.0%	100%	0.0%	100%	0.3%	100%
2002 Average Wage		\$43,725	\$55,919	\$37,460	\$73,162	\$66,407	\$53,939	\$57,759	\$71,118

Table 8 – Hawaii Life Sciences Assets

Educational Assets	<ul style="list-style-type: none"> • Strong academic research programs at UH and Hawaii Pacific as well as several federal-funded initiatives • Growing programs in biosciences and related programs in key sectors
Research Assets	<ul style="list-style-type: none"> • Small research facilities affiliated with universities • Significant investment in research facilities from key industry examples (seed, plant, marine)
Anchor Firms	<ul style="list-style-type: none"> • Only embryonic firms in human biotechnology. No significant success stories, yet Hawaii Biotech is fast emerging on the global stage. Consider Tripler as an ‘anchor firm’
Political Support	<ul style="list-style-type: none"> • Strong political support from the senior U.S. Senator, Governor, Office of Economic Development, Legislature as well as local leaders
Cross-Institutional Collaboration	<ul style="list-style-type: none"> • Strong tradition in most institutions of research and training collaboration among each other and to many external top-notch institutions • Increasing joint resource commitment towards senior scientists and investigators as well as shared positions and roles
Financial Assets / Investor Support	<ul style="list-style-type: none"> • Region is home to many wealthy individuals as well as expatriates, significant ties to international firms, and a well developed banking-financial-trust investment sector • There is little tradition of venture capital or risk financing in these scientific and technological areas
Related Industries	<ul style="list-style-type: none"> • The Hawaii region is home to strong telecom, military-related and agro-industrial firms as well as flexible manufacturing

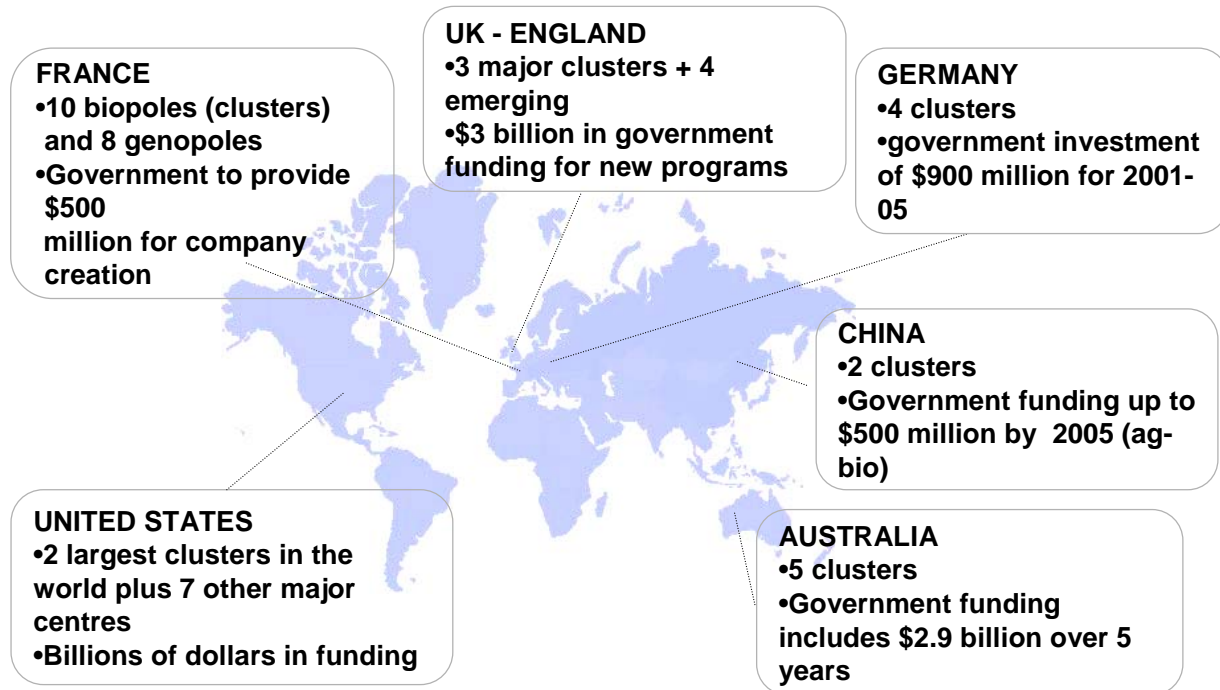
4.3 - The Competitive Landscape

As the baby boomer generation continues to age, the emphasis placed on healthcare and its various facets continues to grow. Developments in research labs across the world have allowed the population to enjoy increasingly longer life expectancies. Despite these breakthroughs, the cure for many life-threatening diseases remains elusive and the cost of healthcare continues to rise at an alarming rate. However, solutions emerging through biotechnological developments and discoveries can help to reduce these costs, increase productivity and enhance overall patient care. Savings – in the trillions – could be realized with the production of life-saving treatments and drugs to both prevent and cure diseases such as heart disease.

As technology and innovation continue to drive developments and change health-care and wellness paradigms across all aspects of our lives, so too does it result in a shift in the healthcare industry’s approach to preventive treatment of these diseases. Using biosciences, researchers are attempting to use gene therapy and other revolutionary treatments to combat these omnipresent diseases. Significant attention and dollars are devoted to bio-related research, which represents a huge opportunity for regions with the critical mass, capacity and commitment to develop and support a thriving biosciences industry.

Global Perspective of Business Development and Competition:

Figure 2 - World Leaders in Biotechnology are already Realizing Economic Gains^{iv}

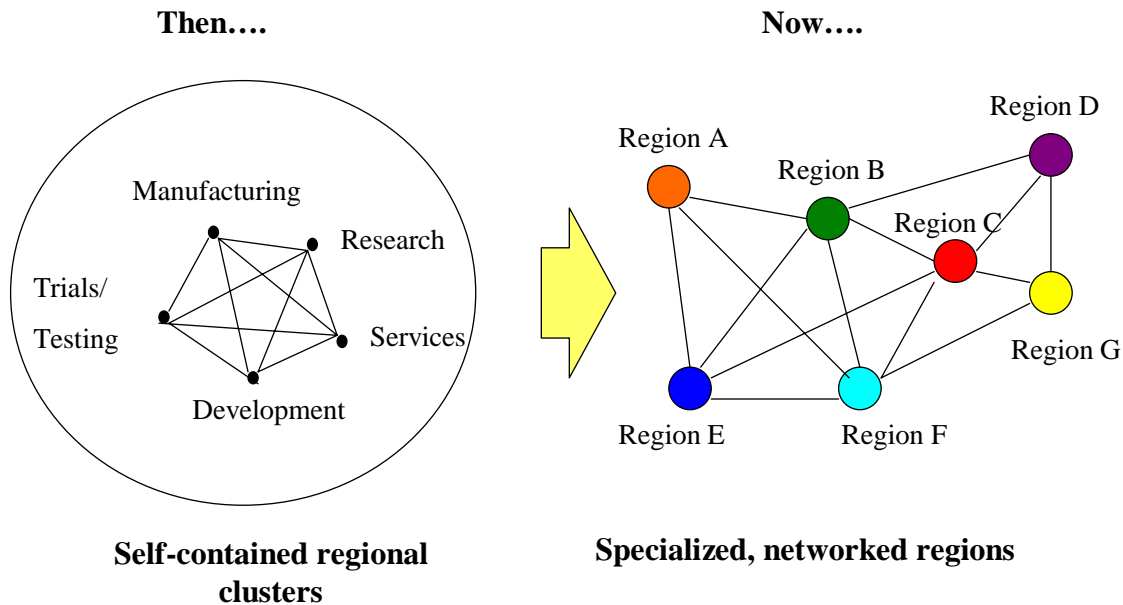


Source: *New Economy Strategies, 2003; The Brookings Institution Center on Urban and Metropolitan Policy, 2002*

Some 40 regions in the United States and approximately 17 around the world are racing to develop the next generation of biosciences clusters. From Singapore to Australia in the Asia-Pacific, from Saskatoon to Toronto in Canada, and from Cambridge to Paris in Europe, global competitors are creating competitive advantages and niches in specific biosciences arenas.

Formation of a statewide strategy must take into account the realities of a global marketplace – research and development generally occurs in several countries before reaching the marketplace. Ireland and Scotland alone are home to more than 50 major pharmaceutical outsourcing facilities, while Mexico has over 100 production and manufacturing facilities. Nearly all of the largest U.S. companies have facilities distributed throughout the world and do most of the production outside of the country. More than 60% of major U.S. pharmaceutical companies are now outsourced business models whereby key elements of research, production and manufacturing are less integrated into the physical proximity of headquarters, and thus provide Hawaii an opportunity to attract vital pieces of global ‘footprint.’

Formation of strategies that seek to attract, recruit, market, and promote Hawaii’s biosciences requires a global perspective – even though the United States is still the dominant driver of biosciences, the Asian ‘tigers’ of China, Korea, Taiwan, and Singapore are poised to leapfrog this competitive position within the next eight to 10 years.

Figure 3 - Inter-connected Hubs and Nodes

Evidence gathered during more than thirty projects in various locations in the U.S and abroad, as well as from the tracking of forty-five regions nationally and globally, has led NES to conclude that the traditional self-contained cluster model is evolving into more specialized networks. Thus NES has created the concept of **Global Hubs and Global Nodes**. This mirrors the fundamental change in the business model for the very industries comprising the clusters in most states and countries. Over the past twenty years, the regional economic development model based on Dr. Michael Porter's initial work on clusters at Harvard University has been transformed by the influence of a number of factors, including outsourcing, decentralization, and non-localized vendor-supplier chains. To analyze and benchmark the future challenges and opportunities for Hawaii, recognition of this transformation requires new thinking and the designing of appropriate responses.

NES has sought to examine the current asset-base of the Hawaii cluster within the borders of the state, and then sought to examine that asset-base relative to networking with other U.S. and foreign locations. Those regions in the world that are committing resources and plans towards connecting their assets and infrastructure for life science development are the regions who are becoming the leaders in the relentlessly competitive life science economy.

While NES does not advocate rankings and benchmarking one state against another, it is instructive to examine the rate by which leading and emerging states are garnering resources to compete in the life sciences. There are a number of anecdotal stories and data-points behind each of these next two charts (R&D Performance and Industry Funding). Based on analysis of Hawaii in critical input measures for research and development, key messages emerge:

- Hawaii must create a statewide and multi-institutional funding strategy to identify and attract federal, state, private sector, industry, international and philanthropic resources to invest in the life sciences

Both improved communications and strategic discussions with industry partners are necessary to increase the level of private sector investment in Hawaii's potential scientific and technological targets of opportunity.

National Perspective - Innovative State Policies to Encourage Bioscience Development:

In the United States, the formation of biosciences/life science clusters is considered a mandatory strategy of regional and state economic development. Many states have instituted public policies that enhance the environment for growing their clusters. For instance, the New Jersey strategy allows emerging, growth companies to sell their early losses to more established firms – thereby creating a new pool of investment dollars in exchange for favorable consequences against state income taxes. These so-called “carry-forward losses” have increased the number of startups in the New Jersey region. Other state policies include incentives for the relocation of outsourced divisions from global biosciences companies, investment in life-science related infrastructure that hosts newly-commercialized university research, and recruiting highly-regarded research teams.

For Hawaii to compete in the emerging bioeconomy, it must develop a portfolio approach to its strategies and tactics. Act 215 is not enough. Continuous new and innovative incentives will have to be created in science and technology commercialization, workforce, and the specific research process. Kansas' \$500 million *BioAuthority*, California's \$1 billion in stem cells, Texas' new \$100 million emerging technology fund – these and other examples are challenges to Hawaii's next stages of implementing the Road Map.

After 25 years of observing the nascent biosciences industry maturing and the success of vital clusters developing in other industries, regions worldwide are coming up with their own strategies to acquire — and maintain — a major piece of the healthcare industry pie. After several years of constant scanning, dialogue with, and travel around the United States, NES has begun to capture the unique activities and approaches underway to recruit, attract, and retain the scientists and entrepreneurs that form their own biosciences clusters. The data suggests that concentration is occurring in a handful of regions. These states and regions have developed a continuous pipeline of strengths for the creation of targeted chemical compounds and materials leading to new drug discoveries and products.

Clinical Trials and the Impact on Bioscience Development:

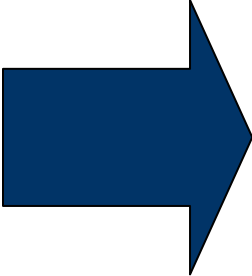
One area of interest for Hawaii and its competitor states is the organization, recruitment, and execution of clinical trials. Over a period of 2004-2005, Hawaii has led the nation in the number of clinical trial proposals – 544 as compared to California's 510 and Texas' 484. These proposals are global pharmaceutical and biotech companies seeking to access populations and demographics that contribute to their knowledge and analysis of potential compounds and drugs leading to solutions for cancer, cardiovascular, neurological, and gastrointestinal subject matter

(the primary focus of trial activities in Hawaii). Increasing numbers of trials in the next generation of proposals – and completed trials – have included infectious diseases, virus, and related diseases transmitted commonly through human and animal interactions.

Not only does the entire range of impact from clinical trials have importance to the competitive environment in the U.S., but emerging trends in scientific and technological activities are having significant impact on the economic and business models of clusters.

As Table 9 shows, a transition has been occurring over the past ten years with significant trends creating specific impacts on the competitive advantages for cluster development. Hawaii must consider these trends as important ‘signs and lanes’ on the Road Map.

Table 9 - Key Biosciences Trends and Cluster Implications ^v

Key Biosciences Trends:		Cluster Implications:
<ul style="list-style-type: none"> • Maturing Biotechnology Business Models 		<ul style="list-style-type: none"> • Increasing demand for manufacturing and commercial capabilities
<ul style="list-style-type: none"> • Developing technologies in Life Sciences 		<ul style="list-style-type: none"> • Creation of new opportunity with convergence of IT and biotechnology
<ul style="list-style-type: none"> • Emerging personalized healthcare model 		<ul style="list-style-type: none"> • Need to address global markets to find profitable scale of patient population
<ul style="list-style-type: none"> • Rising cost of healthcare 		<ul style="list-style-type: none"> • Pressure to improve the cost and efficiency of drug development
<ul style="list-style-type: none"> • Change in funding model 		<ul style="list-style-type: none"> • Need for creative capital solutions and understanding of biotechnology model
<ul style="list-style-type: none"> • Changing regulatory environment 		<ul style="list-style-type: none"> • Converging global regulatory standards and emphasis on IP protection
<ul style="list-style-type: none"> • Growing public interest in the ethics of Life Sciences 		<ul style="list-style-type: none"> • Risk of public unwillingness to accept certain technologies and applications
<ul style="list-style-type: none"> • Increasing competition from other regions 		<ul style="list-style-type: none"> • Competition for capital, resources, Intellectual Property
<ul style="list-style-type: none"> • Expanding international scope of Hawaii companies 		<ul style="list-style-type: none"> • Opportunity in new global markets

Regions and states are amassing the resources, talent, and capital necessary to advance their commercialization and economic development agendas. Over \$18 billion in new resources has been identified and nearly 22 million square feet in new infrastructure are being developed that will make several U.S. regions strong competitors in certain areas of science and technology. These new dollars include initiatives in recruitment, disease-oriented research, and seed and venture capital formation. The square footage increase includes research and commercialization facilities as well as collaborative space for new enterprise formation.

Several regions such as St. Louis, Pittsburgh, Atlanta, and New York City are initiating large scale projects to advance biosciences as a priority in their regional economic agendas. These regions have not acted solely for the benefit of a handful of entrepreneurs and innovators, but instead to enhance the resources and environment for accelerating new discoveries that benefit patient care for the entire population. While each of these regions has their own characteristics and unique culture, common among them are the mechanisms and leadership in place that facilitate the movement of ideas from lab to market in a constant and smooth progression of discovery and development.

Competitor States:

Fixating on the successes and failures of other states and regions runs the risk of becoming an unhealthy obsession which does nothing but distract Hawaii from its primary goal of becoming a leader, not a follower. Nonetheless, using other states as a frame of reference can be quite useful, if taken in the proper context. Hawaii can learn a lot about its competitive position by benchmarking both its current assets and its progress towards its goals against other US states. In so doing, it is useful to look at two groups of competitor states – one group composed of the states which are recognized as national leaders in the life science industry (California, New York, Pennsylvania, Maryland, Texas, and Massachusetts), and one group composed of comparative states with similar emerging life science qualities (Kansas, Iowa, Missouri, Colorado, Oklahoma, and Nebraska), especially related to crop production, human health, and existing programs in telemedicine or similar IT related functions.

Table 10 – Aggregate and Personal Economic Indicators, Hawaii and Competitors, 2003^{vi}

States		Gross State Product (GSP) (millions of \$)	National Rank	GSP <i>per capita</i>	<i>Per Capita</i> Personal Income	National Rank	2003 Population (millions)	National Rank
Leading States	CA	\$1,446,430	1	\$40,763	\$33,415	12	35.48	1
	NY	\$821,667	2	\$42,817	\$36,112	6	19.19	3
	PA	\$449,947	6	\$36,389	\$31,911	18	12.37	6
	MD	\$212,444	16	\$38,563	\$37,446	5	5.51	19
	TX	\$813,112	3	\$36,761	\$29,074	30	22.12	2
	MA	\$297,343	13	\$46,222	\$39,504	4	6.43	13
Emerging States	MO	\$194,611	20	\$34,118	\$29,464	27	5.70	17
	CO	\$187,120	21	\$41,116	\$34,561	8	4.55	22
	KS	\$93,352	31	\$34,270	\$29,438	28	2.72	34
	IA	\$103,053	29	\$35,004	\$29,043	32	2.94	31
	NE	\$65,793	36	\$37,834	\$30,179	24	1.74	39
	HI	\$47,066	41	\$37,413	\$30,913	21	1.26	43
US Total	\$10,911,103	N/A	\$37,026	\$31,472	N/A	294.69	N/A	

The national leaders provide Hawaii with concrete examples of what Hawaii can aspire to achieve, as well as useful ‘best practices, best principles’. The six leading states have made important investments in basic and translational research, organized seed-angel-venture capital, sought out unique national and global partnerships, and taken risk to strengthen unique assets and resources within their clusters of industry and entrepreneurship.

Five states (Missouri, Colorado, Kansas, Iowa, Nebraska) identified as “Emerging States” provide Hawaii with a glimpse at similar opportunities and strategies to use as benchmarks for different reasons, and not just because they share a geographical border. Similar geographic locations, geographic sizes and economic and societal histories mean that these states have some interesting qualities for consideration:

- While contiguous to each other, the Great Plains of the U.S. are somewhat isolated from the coasts of the country where the depth and base of investment and activities are viewed globally as ‘world class.’ In interviews conducted among these states, NES has learned that their mindset is termed as the “fly-over states” – suggesting the perception that the rest of the U.S. passes on investing significant energies and resources in limited scenarios found in these regions.
- However, over the past five years, these states have adopted specific strategies and tactics on which to leverage their traits in plant, animal, medical device, health care IT, and demographics into successful life science plans. Each of these states’ governors and legislatures has committed reputations and resources towards advancing their competitiveness in the life sciences.
- A majority of these states are designated EPSCOR regions but wish to advance beyond that level of federal research subsidy to obtain a higher ranking in the eyes of principal investigators, scientists, and industry.

5 – Assessment Methodology and Approach

Overview of Work Plan:

New Economy Strategies' work plan included hard data collection and analysis, anecdotal commentary and stakeholder perspective, regional engagement of vital partners and end-users, and ultimately an overarching exposure and awareness of the biosciences as an economic engine for Hawaii's competitiveness. The goal of this multi-faceted approach was to reach consensus for a statewide road map and implementation plan that built on the current bioscience efforts and highlighted emerging target areas for future investment.

The Hot Team Process:

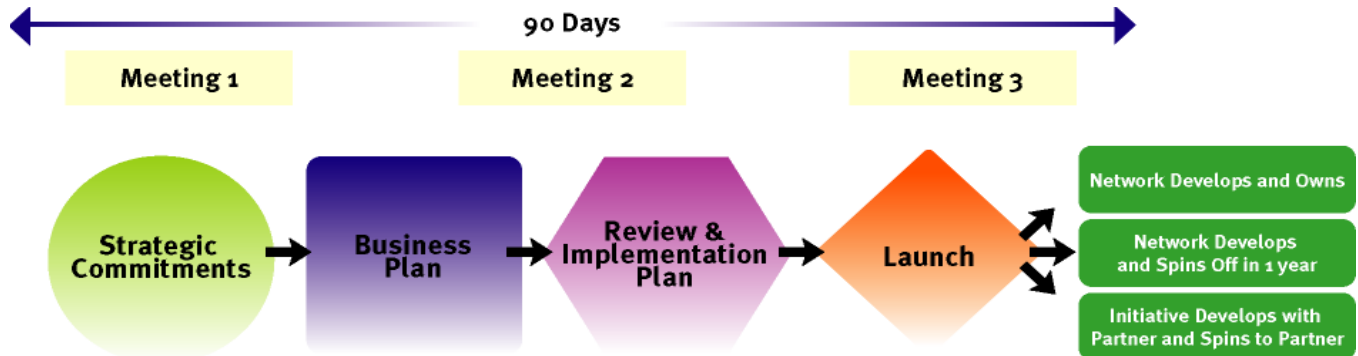
The Hot Teams played an integral part in creating the Road Map. The Hot Teams were comprised of 12-18 individuals representing key academic and non-profit institutions, industry players, entrepreneurs, and other key stakeholders. The Hot Teams evaluated Hawaii's existing assets and competencies in the Target of Opportunity areas, and determined the state's ability to exploit these opportunities to compete in the global marketplace.

The Hot Teams chose the best of the more than forty ideas that came out of the process for further development and wrote detailed business plans outlining their expected impacts as well as strategies for their implementation. The Hot Teams used their entrepreneurial knowledge and subject matter expertise to design business plans which:

- Inventoried assets and their inter-relationships,
- Raised the visibility and credibility of existing initiatives and efforts that require greater attention for success, and
- Encouraged partnering with often-competing institutions and individuals that see highest common purpose through collaboration.

Figure 4 below details the precise flow of the work for each Hot Team, the desired results of each work session, and the expectations for action and implementation.

Figure 4 - Hot Team Process ^{vii}



Strategic Commitments:

- Define what Hawaii must do to be viewed globally as an innovative location
- Identify and engage all of the existing organizations, institutions, and individuals working towards a similar strategic commitment
- Create statements of action including specific commitments to work towards completion

Business Plan:

- Develop a succinct two page business plan identifying requirements, determining expectations for resources, and naming champions to lead implementation
- Identify the resources (time, money and reputation) necessary for success
- Articulate what the impact and outcomes will be for the region's future

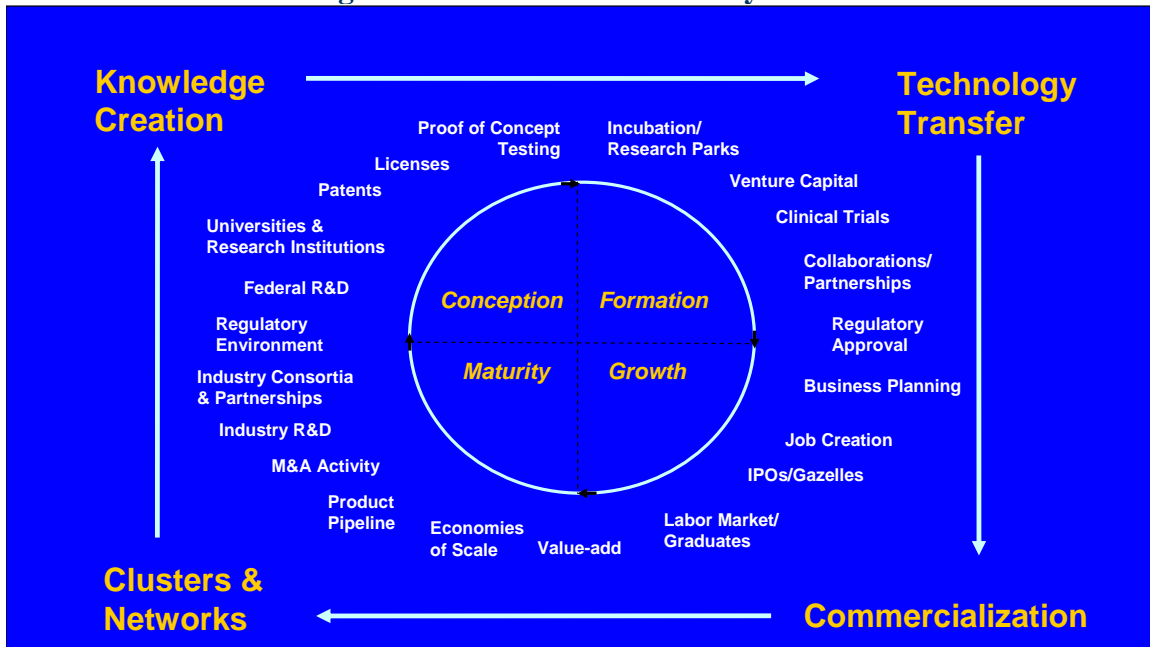
Review and Implementation Plan:

- Design an implementation plan that is actionable, sustainable, and measurable
- Identify five to ten vital performance metrics that will hold the region's "feet to the fire" regarding the implementation of the plan

The Innovation Lifecycle®:

The Innovation Lifecycle® is a four stage repeating cycle describing the life of a product or service, beginning with idea conception, moving to formation, then to growth and finally to maturity. The “cycle” in Lifecycle refers to the new company generation and spinout that occurs from mature firms, thereby completing the cycle and beginning anew. The Hot Teams evaluated both the targets of opportunity and their business plans within the context of the Innovation Lifecycle®, explaining how their ideas would impact on each of the four stages.

Figure 5 – The Innovation Lifecycle®^{viii}



The Four Stages of the Innovation Lifecycle®:

- 1) The **knowledge creation/conception** stage is the development phase. This involves idea generation, research and development, and patents. Crucial in advancing to the next stage of the Lifecycle® are internal, federal, “angel,” and/or entrepreneurial capital.
- 2) The **technology transfer/formation** stage is typified by clinical trials, regulatory filings, and business planning, a phase in which the product/process proves its worth. Entrepreneurial services and support structures, investment capital, and partnering are needed to progress to the next stage.
- 3) Following clinical trials and regulatory approvals, the product/process enters the **commercialization/growth** stage. At this time, a company usually hires additional personnel, files an IPO, and begins early stage manufacturing production.
- 4) At the **cluster and network/maturity** stage, the company begins to perform in a more traditional fashion: analyzing internal business processes for improved efficiency, developing long-term marketing objectives, and, most important, delivering the product or process to the public.

6 – Qualitative and Quantitative Data

6.1 – Qualitative Data - Survey

NES developed a tool to gauge perceptions and values placed on the entrepreneurial and innovation cycle within the state of Hawaii. From a suggested field of more than 1,000 respondents, we sought to measure and identify ways to close the gaps in what limits the region's capacity to advance ideas from the bench to the market. The survey also provides a set of key actions and recommendations from which a new regional model of collaboration could be found that would link and leverage programs at academic research institutions, the private and public sector, and entrepreneurial interests. The survey received 655 responses with an overall 26% response rate from the targeted list.

Survey Results and Highlights

People in Hawaii are relatively upbeat about the innovation environment and the promise of technology as a driver of economic benefit; 60% felt the environment for innovation is good to average, while 26% were fair to negative. However, 40% felt prospects for an improved setting over the next years were “good.” Survey respondents were nearly split on whether to recommend Hawaii as a relocation for business and professional contacts – 44% were very to likely recommend, 53% were somewhat or not likely to encourage relocations.

Table 11 - Survey Respondents' Satisfaction with Business Climate Factors in Hawaii

Business Climate Factor	Satisfied/Very Satisfied	Neither	Dissatisfied/Very Dissatisfied
Quality of Life	80	13	7
Access to Venture Capital	18	38	43
Regulations on Business	14	29	57
Cost of Doing Business	11	21	68
Quality of Research Universities	39	36	26
Quality of K-12 Math & Science	8	22	69
Collaboration between Businesses, Universities, Government	24	31	45
Interaction amongst Innovators, Entrepreneurs, Venture Capitalists	28	45	26
Overall Entrepreneurial Mindset	19	35	47
Talent Recruitment (attract)	22	40	37
Talent Recruitment (retain)	19	46	34

Because of rounding, totals may not equal 100%

As Table 11 above shows, by far the most significant positive finding of the survey was that 80% of respondents approved of the quality of life in Hawaii. The most resounding negative findings, on the other hand, were that only 18% approved of the access to venture capital in Hawaii and 19% felt strongly about Hawaii's entrepreneurial mindset. Challenging these negatives were answers to two distinct measures of personal perspective and behavior: 92% strongly agree/agree that entrepreneurship is a viable choice for career paths, and 68% disagree/strongly disagree that business failure equals personal failure. The door is open to connecting resolution of the venture and mindset weaknesses with the very positive beliefs about future professional opportunities in the entrepreneurial world of Hawaii in the 21st century.

Demographic break-down of respondents is informative: only 11% are 39 years or young, 40% are 50-59 years of age, and 25% are 40-49. Over 65% are in senior management positions of their firms, organizations, or institutions. Thirty-six percent were born in Hawaii, while 35% moved to Hawaii as an adult for professional opportunities. Seventy-four percent of respondents manage firms founded in Hawaii versus those relocating from other communities. Thirty-one percent are small firms (1-10 employees) while 20% represent entities 101-500 and 16% represent entities of 1000+ employees.

The fields of management and industry sectors represented in the survey include 30% from a broad base of businesses, 15% from business services, 10% from academia, 8% education and knowledge, 7% financial services, 6% from both IT/Software and public sector respectively. A good mix of industries, age groups, and professional duties has created a solid snapshot of opinion and recommendations from the survey!

These results underscore the fact that increasing Hawaii's bioscience competitiveness is not merely a question of changing the regulatory or tax environment – rather, it is a question of increasing collaboration, cooperation, and leadership across and between all involved institutions, entities, and regions. Certainly, the results show that there is room for improvement concerning many of Hawaii's fundamentals. But the most telling results point to collaborative answers – increasing Hawaii's branding and marketing efforts in order to attract new businesses, workers, and researchers, for example.

Impact: The results of the survey generally confirmed and reinforced other findings. Survey participants agree that Hawaii is both a great place to live and a good place to do business. However, they also agreed that the state is failing in important areas, such as attracting the funding and talent that are critical to the development of a successful life science economy.

6.2 – Qualitative Data – Interviews and Talk Story Sessions

NES determined, at the outset, that individuals and institutions within and beyond the region could provide valuable insight, knowledge, and anecdotes about Hawaii's competitiveness and innovation process in biosciences. Talk story sessions were held throughout the state to share preliminary findings, generate feedback on initial recommendations and gauge perceptions and mindsets of stakeholders and leaders.

Talk Story Session and Interview Results:

- **Common Themes External to Hawaii:**
 - Outsourcing is a pervasive threat or opportunity depending on the region
 - Singapore, China, Korea, Australia and New Zealand are clear competitive threats OR unique opportunities for Hawaii
 - With technology, many businesses can be conducted anywhere – good news & bad news for Hawaii – so why must I be present to 'win' in Hawaii?
 - Borders are invisible to diseases and the spread of new infections – identifying, responding, and ending the spread into North America is an opportunity for Hawaii
 - Hawaii's demographics represent the future of the US and world for clinical trials
 - Fed R&D is going to Life Sciences but often through other clusters (aerospace & defense, advanced manufacturing, nanotechnology, energy and environment)
- **Competitor Perspectives:**
 - The Leading States (California, Texas, Maryland, Pennsylvania, etc.): have completed the cycle of initial life science dominance BUT now seek partnerships beyond their own borders
 - The Emerging States (Missouri, Kansas, Iowa, Colorado, etc.): face similar challenges as Hawaii – middle section of the U.S. is just as isolated from significant federal research and VC dollars
 - The Leading Countries (UK, Germany, Canada, etc.): seek relationships on clinical trial and product development
 - The Emerging Countries (Ireland, Brazil, Mexico, etc.): bound by challenging political or entrepreneurial mindset to connect discovery to commercialization practices
- **Best Technology Bets:** Several breakthrough areas are emerging across the state:
 - High through-put Computing
 - Plant Genomics
 - Detection, Response Sensors & Related Technology for Infectious Outbreaks
 - Health Information Data Management
 - Deep-water Technology
 - Bioconversion Energy Systems/Alternative Fuels
 - Imaging, Digital Tools
 - Telecom-Wireless-Broadband Delivery (Telemedicine)

Recommendations from the Talk Story Sessions and Interviews:

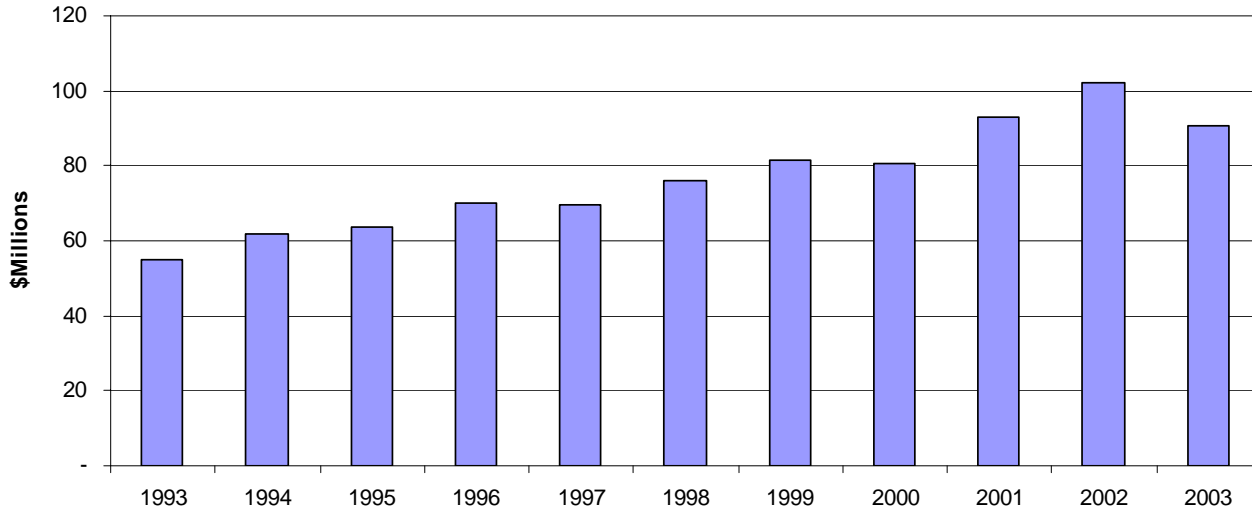
Adopt an Integrated Approach to the Life Science Cluster

- **Cluster Definition and Interaction:** Redefine the cluster map to reduce fragmentation and to leverage and connect the best technology bets across sub-clusters, regions, the state and globally
- **Education and Workforce:** Build and operate under a “workforce continuum” to address the critical disconnect between industry, education and government on short and long term workforce, skills and competency needs
- **Funding:** A statewide funding strategy that addresses effective use of limited state and local resources while leveraging industry, philanthropic and federal-international dollars and inward investment
- **Statewide and Regional Economic Development Strategy:** Seek a better balance between attracting, retaining and growing companies and mount an effort to get all Hawaii’s resources aligned (transportation, academic, health agency, etc.)
- **Communications:** Launch ongoing, proactive regional and statewide effort to regularly inform stakeholders and others about progress in strengthening the cluster and to continuously inventory activities, practices, resources, assets and people

Impact: Participants stressed that Hawaii must find unique, distinguishing assets on which to ‘leap-frog’ the competitive environment in the biosciences. Hawaii needs to assess its current strengths for future relevancy - strengthening the assets, programs, and initiatives that Hawaii already has in place will help it become a national and global leader. Participants highlighted Hawaii’s failure to link, leverage and collaborate to compete globally. Each institution and organization in Hawaii can contribute to the state’s success (be it through technical or scientific expertise, industry experience, or skills and competencies), but they must work together more closely. Hawaii must increase the connectivity and communication across fields of research, commercialization, market development, and branding.

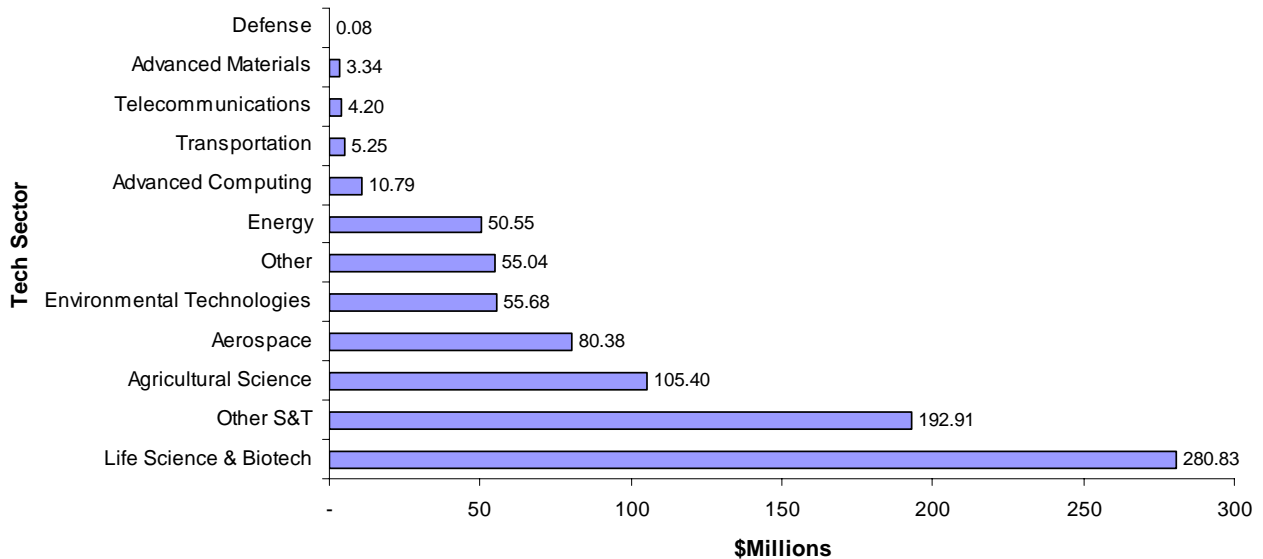
6.3 – Quantitative Data - Federal R&D Funding

Figure 6 - 1993 – 2002 Federal Funding to Hawaii



In the ten year period from 1993 to 2002, Hawaii received a total of \$844.4 million in federal funding. Over \$280 million, went to the life science and biotechnology sector. Federal funding directed at other technology sectors which are important to Hawaii’s bioscience economy included \$193 million to a broad-set of technology sectors and enabling technology discovery, \$105 million to the agricultural technology sector, \$50 million to the energy sector, \$55.6 million to the environmental technology sector, \$80 million to the aviation sector.

Figure 7 - 1993 – 2002 Unrestricted Federal Funding to Hawaii by Tech Sector



Analysis of the National Institutes of Health grants for 1993-2003 suggest that there has been increased research attention on cancer and infectious diseases in Hawaii. The National Cancer

Institute provides the bulk of the funds – over \$94 million, followed by grants for infrastructure from the Center for Research. As Figure 7 shows above, Life Science and Biotechnology receive the most federal funding in Hawaii, although Agricultural Science, Aerospace, Environmental Technologies, and Energy are all large recipients as well.

Table 12 - Research and Development Statistics, Hawaii and Competitor States, 2002^{ix}

States		Total R&D Performance, 2002 (millions of \$)	National Rank	Federal R&D Obligations, 2002 (millions of \$)	National Rank	Total Federal R&D Funding to Universities & Colleges, FY 2002*	National Rank
Leading States	CA	51,388	1	15,686	1	2,726	1
	NY	13,354	5	3,747	5	1,670	2
	PA	9,763	9	3,162	7	1,327	3
	MD	9,030	10	7,192	2	1,303	4
	TX	14,223	4	3,374	6	1,256	5
	MA	14,316	3	4,659	4	1,196	6
Emerging States	MO	2,478	26	1,203	22	519	12
	CO	4,218	19	1,609	19	434	17
	KS	1,865	28	291	38	119	36
	IA	1,346	34	405	32	246	26
	NE	663	40	145	44	99	39
	HI	456	43	375	33	134	33
US Total		255,707	N/A	83,764	N/A	\$21,352	N/A

*Obligations in millions of \$. Includes medical schools

Table 13 - Industry R&D in Hawaii and Competitor States, 2002^x

States		Industry R&D, 2002 (millions of dollars)	National Rank	Per Capita Industry R&D
Leading States	CA	39,664	1	\$1,118
	NY	9,234	6	\$481
	PA	7,064	9	\$571
	MD	3,800	13	\$690
	TX	10,744	4	\$486
	MA	10,279	5	\$1,598
Emerging States	MO	1,592	23	\$279
	CO	2,823	19	\$620
	KS	1,427	24	\$524
	IA	753	33	\$256
	NE	342	36	\$197
	HI	103	47	\$82
US Total		182,403	N/A	\$619

Although industry R&D in Hawaii is at less than respectable levels, when it comes to federal R&D obligations, Hawaii was ranked #33 nationally in 2002 (the latest year for comparison

purposes). One of Hawaii’s top goals over the next three to five years should be to advance from being one of 22 EPSCOR states (states which have historically attracted low levels of federal R&D funding) to become one of the top 25 states for federally-funded science, technology and innovation. Federal R&D funding to Hawaii universities and colleges is entirely concentrated on the University of Hawaii system, with the bulk of that funding (\$121 million of obligations in 2002) going to the University of Hawaii at Manoa (see table 14 below).

Table 14 - Overview of Federal Funding at Hawaii Universities and Colleges ^{xi}

Hawaii Universities and Colleges	Federal R&D Funds Received in FY 2002 (Obligations*)	Degrees Granted					Number of Students		
		BA/BS	MA/MS	PhD	DVM	MD	Undergraduate Students	Graduate & First Professional Degree Students	Total
Brigham Young University – Hawaii	\$0	X					2,278	0	2,278
Chaminade University	\$0	X	X				1,976	585	2,561
Hawaii Pacific University	\$0	X	X				6,759	1,274	8,033
University of Hawaii System:									
Hilo	\$13,122,079	X	X				2,724	189	2,913
Manoa	\$120,815,130	X	X	X		X	12,054	5,478	17,532
<i>School of Medicine</i>	<i>\$10,418,793</i>								
West Oahu	\$0	X					740	0	740

* Obligations are binding agreements that will result in outlays immediately or in the future. Budgetary resources must be available before obligations can be incurred legally, according to the United States Budget.

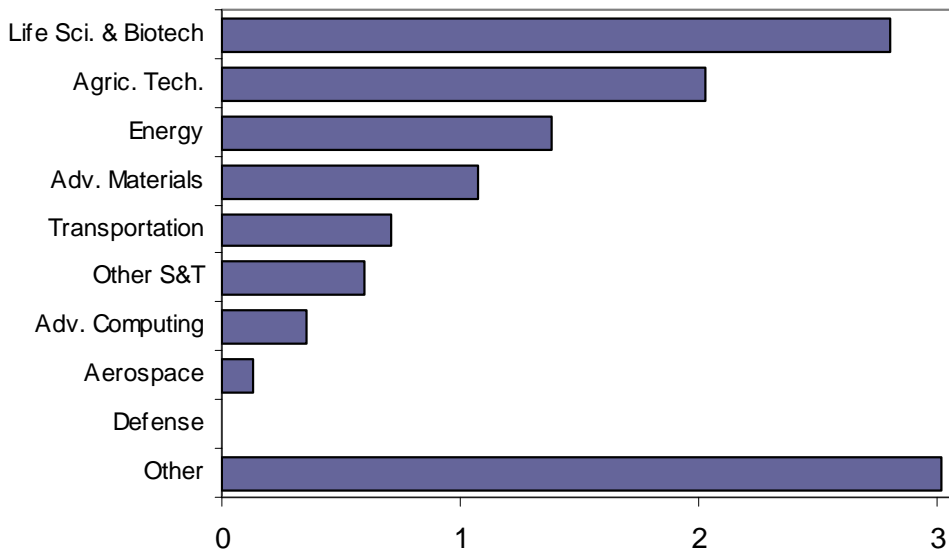
Federal SBIR/STTR Funding:

Description of the SBIR/STTR Programs ^{xii}

The Small Business Innovation Research Program (SBIR) is a highly competitive program that encourages small business to explore their technological potential and provides the incentive to profit from its commercialization. By including qualified small businesses in the nation's R&D arena, high-tech innovation is stimulated and the United States gains entrepreneurial spirit as it meets its specific research and development needs.

The Small Business Technology Transfer Program (STTR) is an important new small business program that expands funding opportunities in the federal innovation research and development arena. Central to the program is an expansion of the public/private sector partnership to include joint venture opportunities for small businesses and the nation's premier nonprofit research institutions. STTR's most important role is to foster the innovation necessary to meet the nation's scientific and technological challenges in the 21st century.

Figure 8 - 1993 – 2002 Unrestricted SBIR/STTR Funding to Hawaii by Technology Sector (millions of \$)



In the ten year period from 1993 to 2002, Hawaii small businesses received a total of \$12.1 million in federal funding under the SBIR and STTR programs. Small businesses in the life science and biotechnology sector received the most funding, followed by small businesses in the agricultural technology, energy, and advanced materials sectors (Figure 8). In the four year period from 1999 to 2002, small businesses in Hawaii received 82 SBIR awards, putting Hawaii in 31st place nationally (Table 15).

Table 15 - Number of SBIR awards, 1999-2002 ^{xiii}

States		SBIR Awards	National Rank
Leading States	CA	3,923	1
	NY	751	6
	PA	663	9
	MD	958	5
	TX	740	7
	MA	2,792	2
Emerging States	MO	88	29
	CO	984	4
	KS	71	34
	IA	45	42
	NE	35	47
	HI	82	31
US Total		19,383	N/A

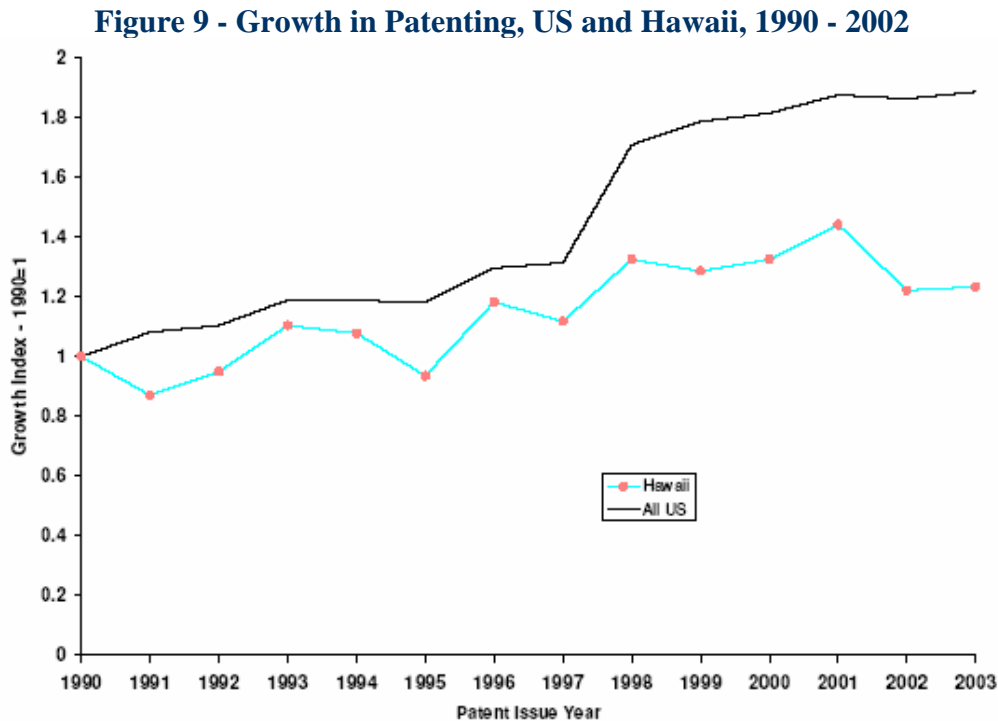
6.4 – Quantitative Data – Patents

Another integral part of the data collection and analysis portion of this process was a comprehensive analysis of Hawaii’s patenting activity, including the number of patents and related citations, scientific and technology strength, and innovation speed. This analysis was conducted by 1790 Analytics, LLC, Inc. of Mount Laurel, New Jersey.

Note that patent activity is often correlated with R&D spending but is not correlated with any other measure of success. As a rule, big companies have a lot of patents and small companies have fewer. Success depends, however, on having a few high impact patents rather than having a lot of mediocre patents. A driving force in technology-based economic development is the ability to convert such intellectual property into new products and services. This, in turn, has positive residual effects for attracting venture and corporate investment.

Patent Activity:

Figure 9 compares patents invented in Hawaii and the United States since 1990. The graph indicates that Hawaii had mirrored the nation as a whole in the early nineties, but is trending flat against the rest of the country in recent years. Note that Hawaii (and the US as a whole) has doubled its patenting since 1990, but in recent years less patenting has occurred in key categories.



Currently the states largest patenting categories include Machinery/Tools, Medical Equipment, Sports-Games-Amusement, then Chemicals, Computers and Peripherals, and Agriculture. The

areas of biggest strength coupled with those sectors as fast-movers in recent years indicate potential convergent technological opportunities for Hawaii in the years ahead.

Significant growth has occurred in four areas of science and technology – Pharmaceuticals, Semiconductors and Electronics, Computers and Peripherals, and Biotechnology – all of which have exceeded 100% growth curves over a comparative five year period. Important for Hawaii is the transition from research and discovery to creation of intellectual property that leads to the manufacturing of new products and services. If a majority of these patents are developed in Hawaii but produce economic benefit in other locations in the world, it signals the need to focus more attention on the capture mechanism in technology transfer and commercialization.

Table 16 - Hawaii Patent Counts by Category, 1990 – 2003 ^{xiv}

Category	# Patents		% Growth
	1990-2003	% Patents	1990-1996 1997-2003
Aerospace	8	1	67
Agriculture	68	5	0
Biotechnology	46	4	129
Boats/Sails/Surfboards	53	4	-34
Chairs/Tables/Sofas/Beds/Household Accessories	63	5	-20
Chemicals	76	6	-10
Computers and Peripherals	70	6	168
Food	25	2	-8
Machinery/Tools/Industrial	124	10	-30
Measuring/Testing/Sensing	57	5	71
Medical Equipment/Medical Electronics	95	8	64
Motor Vehicles and Parts	33	3	36
Pharmaceuticals	55	4	300
Semiconductors and Electronics	12	1	200
Sports/Games/Amusements	92	7	4
Telecommunication	48	4	18
Textiles/Apparel	43	3	69
Other Individual Invented Patents	191	15	45
Everything Else	78	6	0
Total	1237	100	26

Key Findings from Hawaii Patents and Intellectual Property Output:

Impact: In the knowledge economy, the key to success lies in obtaining, creating, developing, and commercializing intellectual property. Although there are significant variations across both regions and technology categories, at a statewide level Hawaii has a solid base of intellectual property. Hawaii has performed strongly in recent years in many patent categories, both in terms of total numbers and in terms of growth rates. However, Hawaii has yet to leverage its patrimony of intellectual property into significant new company creation.

6.5 – Quantitative Data – Venture Capital Investment

Lack of venture capital funding is one of the most oft-cited criticisms of the innovation and entrepreneurial environment in Hawaii. This dissatisfaction felt by business people and other stakeholders is also backed up by the numbers. As Table 17 shows, venture capital investment in high technology industries in Hawaii has been weak over the last decade. For every industry shown, *per capita* venture capital investment in Hawaii was significantly below the national average. The gap in *per capita* venture capital was the significant in biotechnology, where the Hawaii average of \$7.84 was less than ten percent of the national average of \$84.90. The gap in Medical Devices and Equipment was worse while telecom contributed the last percentage over the period analyzed.

Table 17 - VC Activity by Industry, Hawaii and the US, 1995 – 2004 (millions of \$) ^{xv}

Year	Biotechnology		Financial Services		IT Services		Medical Devices		Software		Telecom	
	HI	US	HI	US	HI	US	HI	US	HI	US	HI	US
1995	0	861.4	0	189.4	0	187.1	0	703.2	0	1,125.4	0	1,013.2
1996	0	1,209.6	0	377.6	0	462.2	0	676.1	0	2,265.6	20.0	1,264.4
1997	0	1,482.8	0	425.7	0	627.9	0	1,004.7	0	3,282.6	1.0	1,636.4
1998	0	1,565.1	0	949.4	0	1,125.5	0	1,194.2	0	4,290.8	3.8	2,998.8
1999	0	2,193.9	0	2,289.7	0	4,291.3	0	1,468.5	0.6	9,713.2	12.0	8,274.3
2000	0	4,300.6	0	4,189.3	6.0	9,100.3	0	2,580.4	0	21,433.1	190.0	17,943.9
2001	0	3,343.6	0	1,477.1	0	2,726.1	0	2,048.5	3.0	9,353.8	34.0	6,176.6
2002	2.9	3,032.1	0	468.5	0	1,177.5	0	1,877.1	0	4,696.7	0	2,555.0
2003	2.9	3,566.5	0	425.5	0	777.1	0	1,614.0	0	3,875.7	8.0	1,931.3
2004	4.1	4,014.0	0	334.5	0	718.3	0	1,724.4	0	5,014.2	0.5	1,766.0
Total VC, 1995-2004												
	9.9	24,932.8	0	10,543.1	6.0	20,120.1	0	14,851.7	3.6	69,437.5	268.8	43,644.2
VC per capita, 1995-2004*												
	\$7.84	\$84.90	\$0	\$35.90	\$4.75	\$68.52	\$0	\$50.58	\$2.85	\$236.46	\$212.85	\$148.62

*Total 1995-2003 dollar amount divided by 2004 population, according to US Census Bureau (HI =1,262,840, US = 293,655,404). Blank cells indicate years in which Hawaii had no venture capital activity.

Impact: Because adequate venture capital funding is not readily available, it is more difficult to fund start-up businesses in Hawaii. This is especially true for life science companies, which require a greater investment of time and capital to bring a product to market than do start-up companies in most other sectors. If Hawaii cannot increase the amount of available venture capital funding, it will not be able to achieve the desired rate of new company generation, and it will be difficult to achieve the critical mass of companies which is necessary to the formation of the overall life science cluster.

6.6 – Quantitative Data – Workforce Composition

Table 18 below shows the number of employees and their averages wages in nine of the occupations which are most important to Hawaii's bioscience and innovation economy in 2000 and 2003. Data for the US total are provided so Hawaii can be compared to the national average.

Table 18 – Employment and Wages in US and Hawaii by Occupation, 2000 and 2003^{xvi}

-- Hawaii --								
Occupation	Total Employment			Mean Annual Wage			% of Total Employment	
	2000	2003	% Change, 2000 - 2003	2000	2003	% Change, 2000 - 2003	2000	2003
All Occupations	551,000	553,030	0.4%	NA	\$35,660	NA	100.0%	100.0%
Management	26,990	24,700	-8.5%	\$64,950	\$77,600	19.5%	4.9%	4.5%
Business and financial operations	16,950	19,900	17.4%	\$46,220	\$52,060	12.6%	3.1%	3.6%
Legal	3,770	4,400	16.7%	\$50,500	\$58,050	15.0%	0.7%	0.8%
Computer and mathematical	6,340	7,170	13.1%	\$51,210	\$57,610	12.5%	1.2%	1.3%
Architecture and engineering	7,240	8,110	12.0%	\$52,920	\$58,100	9.8%	1.3%	1.5%
Life, physical, and social science	5,370	6,400	19.2%	\$43,960	\$49,700	13.1%	1.0%	1.2%
Healthcare practitioners and technical	22,890	22,650	-1.0%	\$52,590	\$63,180	20.1%	4.2%	4.1%
Healthcare support	12,150	12,610	3.8%	\$23,830	\$25,120	5.4%	2.2%	2.3%
Farming, fishing, and forestry	1,190	NA	NA	\$20,380	\$22,390	9.9%	0.2%	NA
-- United States --								
All Occupations	131,792	127,567.91	-3.2%	NA	\$36,210	NA	100.0%	100.0%
Management	7,782.68	6,653.48	-14.5%	\$68,190	\$82,790	21.4%	5.9%	5.2%
Business and financial operations	4,619.27	4,924.21	6.6%	\$48,470	\$55,550	14.6%	3.5%	3.9%
Legal	890.91	951.51	6.8%	\$68,930	\$78,910	14.5%	0.7%	0.7%
Computer and mathematical	2,932.81	2,827.01	-3.6%	\$58,050	\$63,240	8.9%	2.2%	2.2%
Architecture and engineering	2,575.6	2,376.65	-7.7%	\$54,060	\$59,230	9.6%	2.0%	1.9%
Life, physical, and social science	1,038.67	1,113.13	7.2%	\$47,790	\$53,210	11.3%	0.8%	0.9%
Healthcare practitioners and technical	6,041.21	6,173.76	2.2%	\$47,990	\$55,380	15.4%	4.6%	4.8%
Healthcare support	3,039.43	3,208.77	5.6%	\$21,040	\$22,750	8.1%	2.3%	2.5%
Farming, fishing, and forestry	460.70	461.63	0.2%	\$18,860	\$20,200	7.1%	0.3%	0.4%

Significance of Table 18:

Employment in management occupations in Hawaii dropped by 8.5% from 2000 to 2003, which may have been caused by the general nation-wide economic downturn over the same period. The state's economy fared significantly better than the nation as a whole during the downturn, however. Overall employment in Hawaii remained stable, and some high-wage occupations (such as those in business support, computers, and legal occupations) registered double-digit growth. Particularly noteworthy was the 19.2% increase in employment in life, physical, and social science occupations (which only increased by 7.2% nationally over the same period), and the 12% increase in architecture and engineering occupations (which shrank by 7.7% nationally, creating an almost 20 point differential in growth rates between Hawaii and the US).

Annual wages in Hawaii in 2003 were similar to the national average in many occupation categories, although some categories differed widely. The overall average annual wage in Hawaii in 2003 was \$35,660, 1.5% below the national average of \$36,210. The similarity between nominal wage rates is deceptive, however, since it doesn't take into account Hawaii's substantially higher cost of living (**the cost of living on the island of Oahu is estimated to be 27% higher than national average**, according to Hawaii's Department of Business, Economic Development and Tourism).¹ Viewed from this perspective, real wages in Hawaii were lower across every occupation category, even those (such as healthcare, farming, fishing, and forestry) which had higher average nominal wages. Particularly noteworthy is the disparity between Hawaii and US averages wages in legal occupations – nominal wages in Hawaii were 26.4% less than the US average in 2003, and that's without taking into account the 27% cost of living differential.

Table 19 – Top Five Hawaii Occupations by Employment, 2000 and 2003 ^{xvii}

Top Five HI Occupations by Employment	2000			2003		
	Total Employment	Mean Annual Wage	% of Total Employment	Total Employment	Mean Annual Wage	% of Total Employment
Office and administrative support	94,710	\$27,230	17.2%	92,300	\$29,180	16.7%
Food preparation and serving related	69,540	\$18,230	12.6%	67,430	\$21,390	12.2%
Sales and related	57,830	\$24,850	10.5%	58,050	\$27,770	10.5%
Transportation and material moving	37,110	\$29,860	6.7%	35,970	\$33,170	6.5%
Building and grounds cleaning and maintenance	33,800	\$21,700	6.1%	32,790	\$23,240	5.9%
Top Five Combined:	292,990	NA	53.2%	286,540	NA	51.8%

¹ http://www3.hawaii.gov/dbedt/index.cfm?section=READ_Library494

Significance of Table 19:

Tables 18-19 show information about the occupation categories which have the greatest impact on Hawaii's bioscience and innovation economy. With the possible exception of the "fishing, farming, and forestry" and "healthcare support" categories, these are all occupations which require a significant amount of education and training, and which pay wages which are considerably above the state and national averages. However, these occupations represent a relatively thin sliver of the overall state economy - none of the categories represented even as much as 5% of Hawaii's overall employment in 2003. Most of these occupations account for a much smaller percentage of the Hawaii economy, such as the "life, physical, and social science" category (1.2% of overall employment in Hawaii in 2003).

Therefore, it is worth remembering that the majority of Hawaii's economy is still comprised of occupations requiring less education and training, and paying much more modest wages. Table 9 illustrates that over half of all employment in Hawaii in 2003 was in one of five categories: "office and administrative support," "food preparation and serving related," "sales and related," "transportation and material moving," and "building and grounds cleaning and maintenance." A high school education would suffice for the majority of these jobs, which pay average annual salaries of between \$21,390 and \$33,170. **The majority of Hawaii workers hold jobs which require no college education and which pay less than either the US average (\$36,210 per annum), or the Hawaii average (\$35,660 per annum).** Nonetheless, as Table 20 shows below, Hawaii has a high percentage of college-educated residents relative to other states. With 28.2% of its residents of 25 years of age or over having at least a bachelor's degree, Hawaii is in 16th place among US states (not including the District of Columbia). The city of Honolulu also performs well – with 34.6% of its residents of 25 years of age or over having at least a bachelor's degree, it ranks 18th among large US cities.²

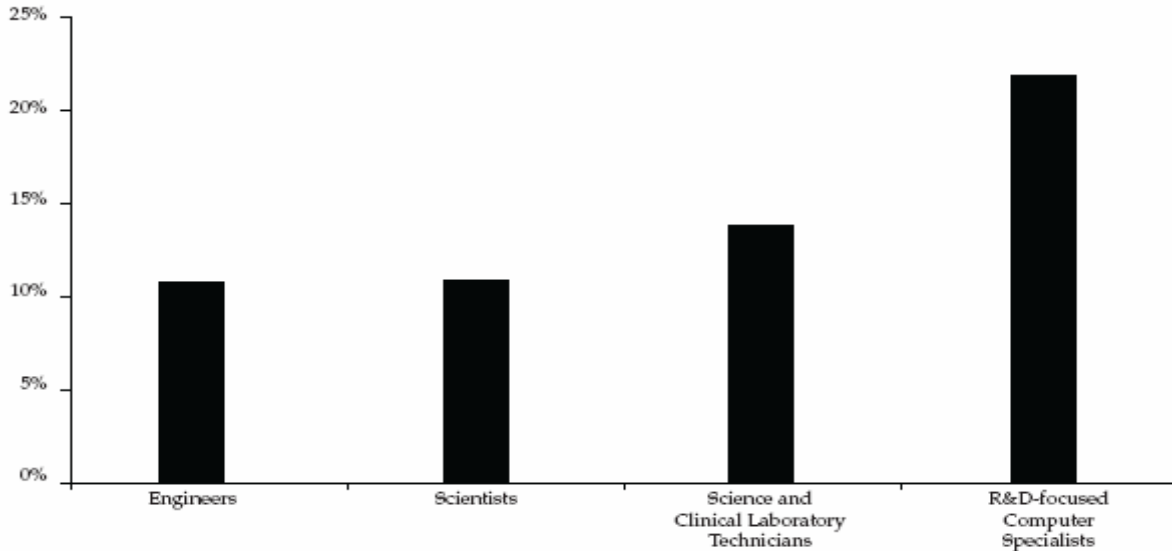
² US Census Bureau, American Community Survey, 2003. A "large" city is defined as having a population above 250,000.

Table 20 – Percent of People 25 Years of Age and Over with at Least a Bachelor’s Degree by State, 2003 ^{xviii}

Rank	State	Percent
	United States	26.5
1	District of Columbia	44.2
2	Massachusetts	35.8
3	Colorado	34.7
4	Connecticut	34.6
5	Maryland	34.5
6	Virginia	32.2
7	New Jersey	32.1
8	Vermont	32.0
9	Minnesota	30.6
10	New Hampshire	30.3
11	Washington	30.2
12	New York	29.7
13	California	29.1
13	Rhode Island	29.1
15	Kansas	28.7
16	Hawaii	28.2
17	Illinois	28.1
18	Delaware	27.6
19	Alaska	26.6
20	Oregon	26.4
21	Utah	26.2
22	Maine	25.9
23	Montana	25.8
24	Georgia	25.7
25	Nebraska	25.3

National Growth in Biotech-related Employment:

Figure 8 - Annual Growth Rate in Biotech-related National Technical Occupations, 00-02 ^{xix}



A 2002 study by US Commerce Department (Figure 8 above) showed strong growth in recent years in biotechnology-related occupations such as engineers and scientists (about 11%), science and clinical laboratory technicians (about 14%), and R&D-focused computer specialists (about 22%). The US Department of Labor predicts strong double-digit growth rates for almost all biotechnology-related occupations over the period of 2002 – 2012 (see Table 21 below).

Table 21 – Biotech-Related Occupations and Their Projected 10 Year Growth ^{xx}

Occupation Title	Number Employed 2002 (thousands)	Number employed 2012 (thousands)	Numeric Change (thousands)	% Change	2002 Median Annual Earnings	Postsecondary Education & Training
Medical scientists, except epidemiologists	58	73	16	26.9	56,980	Doctor's degree
Biomedical engineers	8	10	2	26.1	60,410	Bachelor's degree
Environmental scientists and specialists, including health	65	80	15	23.7	47,600	Master's degree
Biological scientists, all other	27	33	6	22.3	53,300	Bachelor's degree
Biological technicians	48	57	9	19.4	29,040	Associate's degree
Chemist	84	95	11	12.7	52,890	Bachelor's degree
Agricultural & food science technicians	20	22	2	9.3	28,580	Associate's degree
Chemical technicians	69	72	3	4.7	37,430	Bachelor's degree

6.7 – Academic R&D and Science and Engineering Degree Production

Table 22 – Academic and Public Sector Expenditures on Higher Education, 2001 / 2002 ^{xxi}

States		Academic R&D, 2002 (millions of \$)	National Rank	% of Academic R&D Invested in Life Sciences	Amount of Academic R&D Invested in Life Sciences (millions of \$)	Public Higher Education Current-fund Expenditures, 2001 (millions of \$)	National Rank	Per capita Public Higher Education Current-fund Expenditures
Leading States	CA	\$4,882	1	58%	\$2,832	\$22,675	1	\$639
	NY	\$2,774	2	68%	\$1,886	\$13,542	2	\$706
	PA	\$1,913	4	59%	\$1,129	\$6,455	5	\$522
	MD	\$1,880	5	47%	\$884	\$3,141	18	\$570
	TX	\$2,535	3	66%	\$1,673	\$12,744	3	\$576
	MA	\$1,706	6	47%	\$802	\$2,337	27	\$363
Emerging States	MO	\$706	15	81%	\$572	\$2,837	20	\$497
	CO	\$645	19	45%	\$290	\$2,630	23	\$578
	KS	\$300	31	64%	\$192	\$1,831	32	\$672
	IA	\$486	25	67%	\$326	\$2,603	24	\$884
	NE	\$267	35	66%	\$176	\$1,259	36	\$724
	HI	\$173	38	37%	\$64	\$738	40	\$587
US Total		\$36,314	N/A	59%	\$21,425	\$170,024	N/A	\$577

Table 23 – Science & Engineering PhDs Awarded, 2002 ^{xxii}

\$173 million was spent on academic R&D in Hawaii in 2002, putting it in 38th place nationally. Significantly, 37% (\$64 million) of that money was invested in R&D in the life sciences, considerably lower than the national average of 59%. \$738 million was spent on public higher education in Hawaii in 2001, or \$587 *per capita* – just slightly higher than the national *per capita* average of \$577. Hawaii produced 76 science and engineering PhDs in 2002, ranking 41st nationally. 24% of those PhDs were in the life sciences - similar to the national average of 27%.

States		S&E PhDs Awarded, 2002	National Rank	PhDs in Life Sciences	% of S&E PhDs that are in Life Sciences
Leading States	CA	3,232	1	711	22%
	NY	2,124	2	595	28%
	PA	1,207	6	278	23%
	MD	638	11	211	33%
	TX	1,462	3	424	29%
	MA	1,461	4	336	23%
Emerging States	MO	409	20	127	31%
	CO	457	18	101	22%
	KS	275	28	85	31%
	IA	354	22	110	31%
	NE	150	36	36	43%
	HI	76	41	18	24%
US Total		24,558	N/A	6,631	27%

Table 24 – Number of Universities and Colleges Receiving Federal R&D Funding vs. Total Number of Such Institutions in State, FY 2002^{xxiii}

States		All Degree Granting Institutions		All BA/BS Granting Institutions		All MA/MS Granting Institutions		All PhD Granting Institutions		All MD Granting Institutions	
		Total	Receiving Funding	Total	Receiving Funding	Total	Receiving Funding	Total	Receiving Funding	Total	Receiving Funding
Leading States	CA	119	55	104	53	99	50	48	28	9	9
	NY	144	78	130	71	113	66	43	35	12	12
	PA	129	48	122	14	86	35	29	17	6	6
	MD	32	19	31	18	29	17	13	11	3	3
	TX	94	51	86	49	75	46	42	35	7	7
	MA	76	34	69	32	59	28	27	21	4	4
Emerging States	MO	49	14	45	12	33	12	10	7	4	4
	CO	22	49	22	11	16	10	10	8	1	1
	KS	26	8	26	8	18	7	5	5	1	1
	IA	37	14	37	14	21	9	6	5	1	1
	NE	22	5	22	5	16	5	4	4	2	2
	HI	6	2	6	2	4	2	1	1	1	1

About a quarter of the PhD's granted in Hawaii are in the life sciences (table 24). Only two of Hawaii's six degree-granting institutions of higher education receive federal R&D funding. Although Hawaii has prestigious and effective institutions of higher education, their failure to adequately capture federal R&D funding puts Hawaii at a disadvantage vis-à-vis its competitor states.

7 – Findings

7.1 - SWOT (Strengths/Weaknesses/Opportunities/Threats) Analysis

After the qualitative and quantitative data gathering, Hot Teams and members of the Project Advisory Group coupled with the Life Science Council discussed opportunities and barriers preventing the growth of life sciences in Hawaii. This discussion facilitated an analysis of Hawaii’s primary strengths, weaknesses, opportunities, and threats within the life sciences and innovation economy (Table 25 below). By summarizing and distilling the results of the data collection and the Hot Team process, the SWOT analysis presents compelling picture of Hawaii’s current assets and competitive position, as well as illuminating the path that Hawaii should follow to future success.

Table 25 – SWOT Analysis

Strengths	Weaknesses
<ul style="list-style-type: none"> • Highly-educated and hard-working labor force • Generations of expertise in key areas such as plant sciences, information technology, marine, and health-care related • High quality of life • Competitive educational institutions able to attract top-flight researchers • Relatively high concentration of health care, education, and engineering workers • Strong employment concentrations in biological sciences, earth sciences, astronomy, marine, food-related, and health specialties • Important military, defense orientation and mindset for ‘duty’ 	<ul style="list-style-type: none"> • Talent recruitment and retention • Commercialization of Intellectual Property • Lack of venture capital at all stages • High school students lack exposure to Science & Technology career opportunities on the Islands • Below average numbers of math and computer sciences teachers • Relatively low federal R&D funding beyond line-item appropriations • Lack of a coordinated workforce development pipeline • Lack of critical mass of life science firms • Inadequate wet lab space • Lack of a community clearing house for publicizing and coordinating life science initiatives • Hawaii is not effectively marketed outside of the state
Opportunities	Threats
<ul style="list-style-type: none"> • Medical research, specifically oncology and infectious diseases • Consumer health and food safety • Monitoring and managing biological risk • Marine-based consumable water and food products • Biomass and biofuels • Telemedicine, health-related IT • Nutraceuticals • Write more and obtain greater share of research grants through unique collaborations • Leverage strong military presence to realize opportunities • Increase incentives for entrepreneurialism • Improve industry-academia partnerships • Targeted federal R&D funding strategy 	<ul style="list-style-type: none"> • Human Capital Flight (Brain Drain) • Increased competition, both from other US states and globally • Risk of negative perceptions of Hawaii as nothing more than a tourism location in the absence of a coordinated branding and positioning effort • Dwindling base of experienced management professionals • Possible reductions in corporate investment if industry fails to find compelling reasons to have a strong presence in Hawaii • Risk of confusion and loss of focus due to multiple and overlapping state and regional entities involved in knowledge-based, technology-driven economic development • Political controversy regarding science and health policy

7.2 – Cross-cutting Business and Innovation Environment Issues

Throughout the Hot Team process, and supported by initial tactics suggested during the Talk Story forums, a number of cross-cutting business and innovation environment issues were identified. The term “Cross-cutting” was used because the challenges could be found in each of the targets of opportunity. Cross-cutting issues also arose out of the Hot Teams’ discussions for addressing implementation. The challenges – and the respective solutions – will have a significant impact on the innovation environment in Hawaii. By addressing these cross-cutting issues, Hawaii institutions and industries could increase their capacity to innovate scientific, technological and entrepreneurial interests.

While the Road Map process has led to the identification of distinguishing and unique scientific and technological opportunities for achieving competitiveness in the life sciences, the creation of an “ecosystem” at the state, regional, and local levels is critical for sustaining commercialization and societal benefit. Thus, our analysis of crosscutting challenges is intended to recognize the influence positive solutions could have on the emerging business model in Hawaii’s biosciences, as well as on the larger context of catalyzing innovation across institutions, organizations, and individuals.

Four significant cross-cutting issues were identified and examined:

1. **Workforce skills and competencies:**

Survey and regional summit participants recognized that the most critical ingredient to success in the biosciences is the creation of occupation and career paths for Kansans to benefit economically from the growth of the industry. From high schools to community colleges to four-year institutions and post-graduate programs, participants suggested that the state use its existing apparatus within the public and higher education systems, coupled with workforce-employment agencies, to align training, courses, internships and other actions to ensure the successful implementation of the Road Map. Since approximately 150 of the more than 900 occupation codes inventoried by the U.S. Department of Labor have a direct impact on the biosciences, the challenge will be to prioritize the state’s assets in education and workforce to meet the needs of the “Big Ideas” and “Fundamental Actions.”

2. **Infrastructure in support of collaboration and commercialization:**

While Hawaii has made important investments in incubator programs, there is reason to believe that that sort of infrastructure may not be as relevant in the future as it has been to date. While physical spaces should be created that bring teams of researchers together around interdisciplinary discussions for sparking new discoveries and developments, it is also going to be increasingly necessary for Hawaii to advance the social aspects of innovation (for example, through the increased connectivity of principle investigators and industry partners, or of stage-three clinical trials and potential management talent) in order to build new enterprises from such trial methodology. Hot Team members have examined models around the country like USCD Connect, and the best principles from those models have been encouraged across the targets of opportunity as an enhancement for collaboration and commercialization.

3. Early stage, proof of concept and other resources to accelerate the bench-to-market pathways:

The so-called “Death Valley Curve” for discovery and development (the period before a new company starts generating revenues, when it is difficult for the company to raise money) will only worsen as traditional venture capital in the U.S. and abroad seeks earlier returns on investment. Timelines are becoming increasingly difficult, and are shrinking to less than the common eight to ten years of approvals and market-entry. In projects involving research of a more translational nature, the need for short-term cash flow is increasing. Last-stage clinical research with significant commercial potential is fast finding new solutions. For instance, investments made by universities in partnership with industry clusters or agglomerated industry organizations at the early stage (proof-of-concept period) in the wet lab are accelerating pathways off the bench to the market. More than traditional licensing, this is a hands-on approach to shortening the timeframe for sparking innovation.

4. Coordination and integration of communications, research, and opportunities leading to the increased efficiency of resources and energies:

There is a significant intent and willingness to collaborate in Hawaii. For the Road Map process to be successful, these relationships between researchers, principal investigators, and technologists must be strengthened and sustained. There is little idea of how to increase the discussion and socialization at the local and regional levels, and then connect these discussions at the state level. A first step could be identifying the critical communications and awareness for events, programs, and work sessions through a statewide life science electronic calendar. There are many activities and programs across the Islands that could contribute to the growth of life science in Hawaii, yet they can only contribute if they are made aware of and invited to the discussion. The creation of a permanent digital ‘commons’ in the life sciences appears to be an important next step, and converting the ProjectNet developed for the Road Map is a good start.

8 – Hot Team Targets of Opportunity Profiles

Importance of Targeting

Critical to Hawaii becoming competitive in the current technology-focused and agile economy is the ability of the state and its islands to leverage current strengths and opportunities to achieve excellence and become a global leader. Given the breadth and competitiveness of the technology industry, it is impossible to excel in every area. Targeting allows a state and region to hone in on a particular field and gather the specialized resources, talent, and assets necessary to become a premier destination for scientists, researchers, entrepreneurs, investors, and corporations interested in a specific industry.

At the outset, we set a framework for target selection:

- A mix of short-term economic payoff and long-term growth opportunities.
- Areas with a solid foundation in basic science and either realized or potential innovation (patent) activity.
- Existing federal funding flow or the strong potential to attract significant federal funds.
- Collaborative efforts underway or the potential for inter-institutional collaboration.
- The ability to build public and private support around future investment.

Note that each of the selected targets of opportunity represents an area in which Hawaii has the basic foundation necessary to build a competitive advantage in the global environment. The following sections provide a detailed explanation of each of the target areas, as well as the assets and elements Hawaii can capitalize on to create a unique competitive advantage for the region. Federal funding trends, patent data, and other indicators are presented to illustrate the linkages, basis for selection, and the relative strength of the target within the region.

Table 26 – Hot Team Target of Opportunity Profiles

Hot Team	Description
Beyond Brick & Mortar	While acknowledging the importance of real estate, available land, and Kakaako as “the” central location for the life sciences, Hawaii must determine the soft infrastructure of people, skills, capital, and other ingredients
Digital Medical Arts	Through the investments of NASA, National Science Foundation, and DOD, Hawaii has specific elements of communicating ideas and discoveries through creative elements of digital arts (graphics, broadband telecommunications, telemedicine, high-speed bioinformatics, etc.). Bioinformatics is the convergence of computer science, information technology and biotechnology. Telemedicine is the use of telecommunication to provide diagnostic and therapeutic medical information between a patient and doctor without either of them having to travel.
Environmental & Marine Sciences	Biomass, biofuels, biomaterials, and other environmental applications represent a subset of the myriad of applications of advanced biological sciences research.
Integrated Health Discovery & Delivery	Drug discovery and development includes target discovery and identification, lead discovery and identification, drug metabolism and toxicity, drug process and development, and application of genomics, proteomics, pharmacogenomics and bioinformatics in accelerating drug discovery and development. How does Hawaii uniquely tie the discovery successes to the importance of health care delivery among hospitals, doctors offices, specialists, corporate human resources, insurance and third party payers?
Emerging and Persistent Diseases	The Pacific Rim is fast becoming a breeding ground for new forms of infectious disease including avian flu, West Nile virus, and other airborne related health challenges. At the same time, long-plaguing diseases from the Asian and Hawaiian populations (obesity, cardiovascular, hypertension, diabetes, etc.) are increasingly expensive to treat and easily prevented
Plant Sciences	Plant Science is the field of study involving the production, marketing, utilization and study of plants and plant materials; focus on the historical seed and crop related research and production in Hawaii

9 – Recommendations

Table 27 below outlines the “Big Ideas” and the “Fundamental Actions,” and which Hot Teams contributed to which recommendations.

Table 27 – Hawaii Road Map Recommendations: Big Ideas and Fundamental Actions

	Cross-Cutting Initiative:	Hot Team Contributions
Big Ideas	1.) Pan-Pacific Infectious Disease Institute	- Drug Discovery - Health-related IT
	2.) Chronic Disease and Health Outcomes	- Integrated Health - Emerging Diseases
	3.) 21 st Century Digital Medical Arts	- Medical Arts - Emerging Diseases - Integrated Health
	4.) Hawaii Bioproducts Initiatives: Renewable Energy and Biofuels	- Plant Science - Biomass & Biofuels
Fundamental Actions	1.) The Statewide Workforce Continuum: <i>Developing Skills, Competencies and Future Talent</i>	All Hot Teams
	2.) Branding & Positioning: <i>Marketing Hawaii’s Assets Globally</i>	All Hot Teams
	3.) Statewide Funding Team: <i>Gathering Resources for Competitiveness (Federal, State, Industry, Philanthropic \$\$s)</i>	All Hot Teams
	4.) The Hawaii Dialogue	All Hot Teams
Enabling Factors	Statewide Collaboratory: <i>Accelerating Life Science Connectivity through an Infoplex, High-Capacity Computing, and R&D Network for Clinical Trials and Commercialization</i>	- Health-related IT - Drug Discovery

Big Ideas and Fundamental Actions:

Each of the opportunities can be categorized in different ways - from cutting edge product developments, to value-added services and activities, to mechanisms for medical breakthroughs – however, all require the engagement and connectivity of people and institutions across the region. Similarly, each target area will have a myriad of regional impacts and outcomes, including increased employment in the region. New vendors, suppliers, service providers, and related companies will emerge as will a variety of measurable economic consequences and intangibles such as enhanced relationship building and leveraging of existing knowledge. Table 23 outlines the cross-cutting ideas and relationships necessary for implementing the critical elements of the Innovation Road Map.

9.1 - Big Ideas for Global Competitiveness:

1.) Pan-Pacific Infectious Disease Institute

Hawaii's Assets for Institute of Infectious Disease: PRETREAT ALLIANCE

Prevention, Response and Treatment of Emerging Infectious Disease

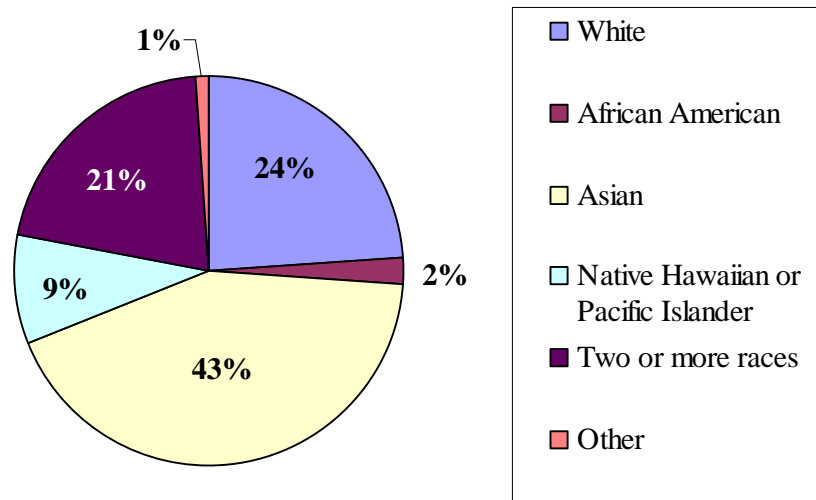
- UH JABSOM
- Biotech Companies
- State Department of Health
- Healthcare Infrastructure

Initiative: Epidemic infectious diseases are once again the leading cause of death worldwide, have devastating economic consequences, and are among the most important public health and economic problems facing the Asian-Pacific region at the beginning of the 21st century. Emerging infectious disease threats include newly recognized pathogens such as Avian flu, HIV, SARS, Nipah virus, Hendra virus. The purpose of the Institute would be to give Hawaii a competitive edge in the discovery and development of infectious disease remote sensing, medical therapeutics and diagnostics.

Description: All of the global public health emergencies in the past 10 years have originated in Asia, i.e., plague in India, 1994; Hong Kong flu, 1997; Nipah encephalitis, 1999; SARS, 2003; and avian influenza, 2004/2005. More effective surveillance, response, and treatment programs must be established using the most modern laboratory, epidemiologic, and information technology. Hawaii's existing scientific, cultural and economic ties to resource-poor developing countries in the Asia-Pacific region and its unique geography put Hawaii in a unique position to provide solutions.

2.) Chronic Disease and Health Outcomes

Initiative: The commitment to design, construct and operate a National Cancer Institute comprehensive cancer center located in Honolulu and tied to the University of Hawaii medical complex in Kakaako requires statewide adoption and utilization of the services and programs offered through this high-profile initiative. The recently released National Institutes of Health Road Map explains that the future investment of resources by entities such as the NCI will encourage greater collaboration across multiple institutions and geographic interests. Therefore, the State of Hawaii should seek to accelerate Dr. Vogel's application and successful award of the comprehensive designation by organizing and integrating research, patient base information, and other elements of the Hawaii Life Science Innovation Road Map targets and tactics in partnership with other hospitals and institutions.

Figure 9 – Hawaii’s Multicultural Population, from 2000 Census ^{xxiv}

Description: The population of Hawaii would benefit from the existence of a Comprehensive Cancer Center in many ways including the availability of innovative clinical trials targeted to benefit Hawaii’s unique multiethnic population. The new anticancer drug gefitinib provides a timely example of this. In a large expensive clinical trial this drug was shown to be marginally effective in the treatment of lung cancer. The primary population in which this drug was tested consisted of Caucasian men who were smokers on the mainland and the drug was found to be effective in only about 10% of patients. Based on its disappointing results in this population it could easily have been rejected for continued use. Subsequently it was found that this drug was dramatically more effective in treating a subpopulation consisting of Asian women who were non-smokers in which nearly a 50% response rate was observed. In the future as we combine our knowledge of genetics and tumor biology with the development of targeted drugs it will become increasingly imperative that we design “smart clinical trials” that are targeted. The absence of a Comprehensive Cancer Center in Hawaii will mean that patients here will be treated with drugs tested in populations that are genetically different and that our population may be treated with less effective or in some cases ineffective drugs and that new potentially beneficial drugs will not be developed.

3.) 21st Century Digital Medical Arts

Initiative: The initiative would have an emphasis on Telemedicine Delivery and High-Through Put Computing.

Description: Bioinformatics is the application of computer science and information technology to manage and analyze the vast amounts of data generated from basic biological research such as nucleotide and amino acid sequences. Bioinformatics assists scientists in managing data and enables interpretation of data by presenting it in useful forms. One of the key drivers of bioinformatics the capacity to transmit, store, and manipulate significant amounts of data around single combinations of genes and proteins related to compounds and chemicals influencing the

response to specific diseases and illnesses. With increasing discovery of sub-molecular elements at the proteomic levels, scientists and principle investigators require additional capacity to compute greater degrees of drug-related developments.

4.) Hawaii Bioproducts Initiatives: Renewable Energy and Bio-fuels

Initiative: This initiative proposes creating a Center of Excellence for Bioproducts. The Center would work to enhance the Hawaii economic base and provide development opportunities in rural Hawaii. Bioproducts, as defined here, are those created from animal- and plant-based resources such as agricultural crops and crop residues, forestry, pastures, and rangelands. Bioproducts includes biomaterials, biochemicals and biofuels. Additionally, a special effort will be made on Biofuels. Hawaii has significant existing resources and companies, and Hawaii is an increasingly important player in alternative fuel production.

Description: Biomass, biofuels, biomaterials, and other environmental applications represent a subset of the myriad of applications of advanced biological sciences research in areas other than human therapeutics. Biomass involves strategies to improve the yield of organic material – plant and animal products – that can be used for processes such as cooking and industrial uses. Biofuel is fuel that is derived from biomass rather than petroleum.

9.2 - Fundamental Actions/Enabling Factor:

From among the SWOT elements, Hot Team members and NES prioritized action-steps that would fundamentally change the prospects for Hawaii's competitiveness by accelerating advantages in unique opportunities or address the short-falls in the barriers limiting the future success and benefit from the cluster. A handful of enabling initiatives are required to meet the needs of the state's capacity to innovate its science, form new enterprises, and spark the correct mindset.

Fundamental Actions/Enabling Factor:

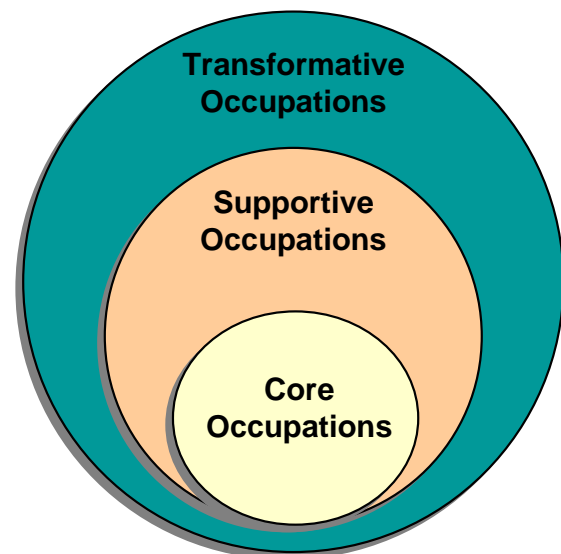
1.) The Statewide Workforce Continuum: Developing Skills, Competencies and Future Talent

Surveys, interviews, summits, and Hot Team members identified the need to coordinate the pipeline of skills, competencies, and training around the end-user of the life science industry. Because workforce is needed with different skills and competencies at different times along the innovation process, a Continuum consisting of public and private sector providers and resources should be organized to respond to current and future demand. The Continuum would map the skills and development around the core, supportive, and transformative competencies that drive the life science cluster, as well as smooth the way for building critical mass of employment and skills opportunities for a wider set of Hawaii citizens.

Core, Supportive, & Transformative Occupations

Some people are core to the success of the industry, others provide supportive roles. Then there are those individuals that could be transformed into serving the industry based on their skills shifting to new opportunities.

- **Core Occupations:** Essential to the existence of the cluster (e.g., programmers, software & electrical engineers, network managers, database administrators)
- **Supportive Occupations:** Necessary to leverage skills and know-how of core occupations (e.g., Electrical & electronics repairers, media & communication workers, math & science teachers)
- **Transformative Occupations:** Necessary to meet emerging technology opportunities (e.g., physicists, library technicians, math/science occupations)



Example: Advanced Manufacturing

(Occupations as defined by the Standard Occupational Classification [SOC] system)

Core Occupations:

- Industrial Production Managers
- Engineering Managers
- Industrial Engineers
- Materials Engineers
- Electrical and Electronic Engineering Technicians
- Electro-Mechanical Technicians
- Industrial Engineering Technicians
- Materials Scientists

Transformative Occupations

- Electrical and Electronics Drafters
- Environmental Engineering Technicians
- Physicists
- Life, Physical, and Social Science Technicians, All Other

Support Occupations

- Transportation, Storage, and Distribution Managers
- Computer Software Engineers, Applications
- Computer Software Engineers, Systems Software
- Computer Support Specialists
- Computer Systems Analysts
- Network and Computer Systems Administrators
- Network Systems and Data Communications Analysts
- Operations Research Analysts
- Statisticians
- Mathematical Technicians
- Electronics Engineers, Except Computer
- Mechanical Engineers
- Engineering Teachers, Postsecondary
- Physics Teachers, Postsecondary
- Commercial and Industrial Designers
- Precision Instrument and Equipment Repairers, All Other
- Electrical and Electronic Equipment Assemblers
- Electromechanical Equipment Assemblers
- Timing Device Assemblers, Adjusters, and Calibrators
- Numerical Tool and Process Control Programmers
- Tool and Die Makers
- Semiconductor Processors

2.) Awareness Campaign: Positioning Hawaii's Assets

The Awareness Campaign would have both an internal and an external focus. The internal focus would be on increasing awareness among current and future stakeholders of the importance for a thriving life science industry – impacting both the economic and societal benefits for all Hawaii residents. The proposal would include a branding effort that might include Technology Celebration Days, Regional Forums on Progress, an annual performance metrics report, partnerships with high schools on career pathways, and popular media articles-editorials regarding the state's strengths and opportunities. The external focus would be on leveraging networks of alumni from Hawaii academic institutions to increase awareness of the state's scientific, technological, and entrepreneurial opportunities for future collaboration, investment, and a 'return home' strategy.

3.) Statewide Funding Team: Resources for Competitiveness

The Funding Team's mission would be to increase the investment of federal dollars into the state's academic institutions, partnerships, and ultimately the requirements around the Hot Teams' centers, initiatives, and institutes. The Funding Team's goals would include:

- Identifying the process by which Hawaii could advance over the next three to five years from an EPSCOR state to one of the top 25 states receiving federal funding for science, technology and innovation,

- Inventorying, identifying, and linking all of the available resources from the private sector, industry, and philanthropy that are emerging as new investors in science and technology along the discovery and development stages,
- Organizing a team of grant-writers, application managers, resource departments and leading committees of Principal Investigators to ensure an increased flow and size of successful funding requests,
- Forming ‘leveraging networks’ to seek out multi-million dollar, multi-year contracts, grants, and investments in select areas of recruitment and attraction of key faculty, research and development teams.

4.) The Hawaii Dialogue: Facilitating the vital conversations and decision-making among residents of Hawaii around science, technology, ethics, and cultural inclusion

Increasingly the world is becoming complex with the introduction of new science and technology discoveries on a daily basis. Opportunities to extend quality of life, improve plant and crop production, eradicate major diseases and a host of other significant outcomes from investing in life sciences also comes with moral and ethical discussions and decisions. For well over 1500 years mankind has faced similar times of challenging faith and science, and our generation is no less plagued by debates and choices which require balanced, purposeful, and neutral platforms for learning and concluding the path to human progress. Because of the unique cultural and place-based heritage of the Islands and its people, the Hawaii Dialogue will create a table for residents – not external interests nor passive but agitating discussants – to participate in constructing a unique solution to address these complex issues.

Enabling Factor:

Statewide Collaboratory: Accelerating Digital Life Science Connectivity

The purpose of the Statewide Collaboratory would be to:

- Continue the successful electronic linkages that were formed during the Hot Team process among academic, industry, regional economic and industry organizations, and public sector agencies,
- Connect Principal Investigators to each other for future grants, contracts, and knowledge sharing on discoveries and development. In turn, connect Principal Investigators and their Teams with Industry, Commercialization and General Applied/Translational Interests,
- Serve as a Statewide Clearinghouse for Research, Enterprise, and Branding-Positioning Targets and Planning,
- Serve as the backbone for sustainable connectivity among the Implementation Teams and Statewide Mechanism-Organizations Responsible for Execution.

10 – Conclusion

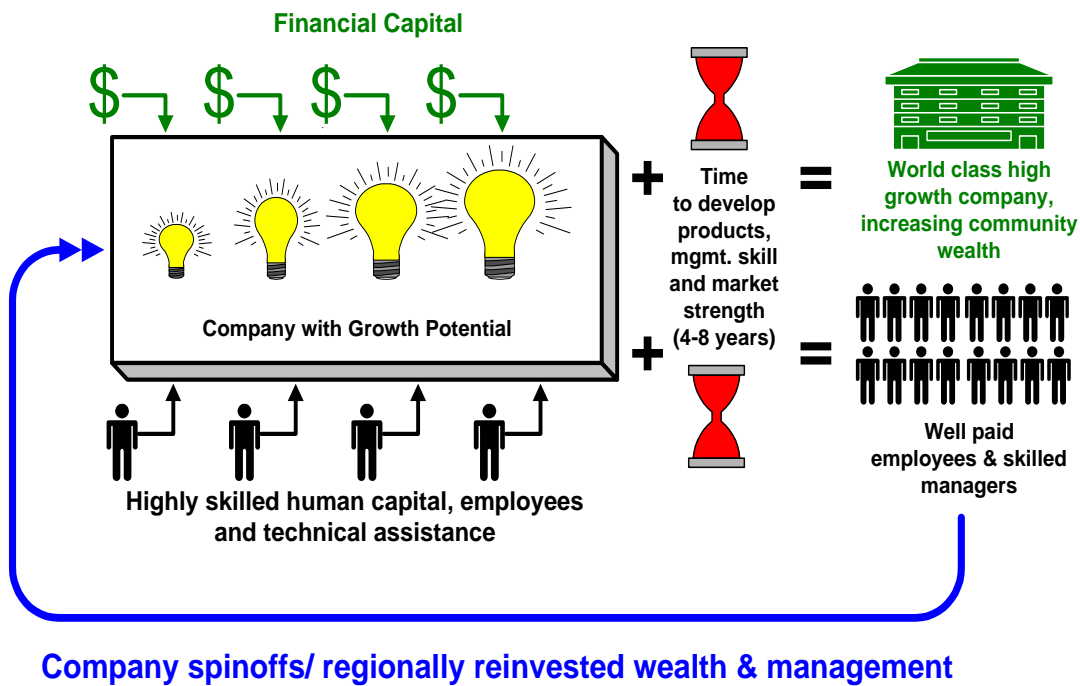
10.1 - Hot Team Implementation Timeline

Table 28 - Hot Team Implementation Timeline

Immediate (0-18 months)	Near-term (18-36 months)	Long-term (36+ months)
Big Idea #1: Pan-Pacific Infectious Disease Institute		
Inventory assets along disease categories. Partnering within the Institute.	Identify and recruit global partners. Identification of priorities for test-bed, pilots (e.g. Gates Foundation, WHO)	Production, spin-off, commercialization of new product. 100% utilization rate by service providers, end-users, deployment
Big Idea #2: Chronic Disease and Health Outcomes		
Encourage greater collaboration across multiple institutions and geographic interests. Partnering within the Fusion Center.	Launch Center sub-category programs; identification of priorities for test-bed, pilots. (e.g. digital demographic pathology laboratory)	Statewide adoption and utilization of the services and programs offered through the comprehensive cancer center.
Big Idea #3: 21st Century Digital Medical Arts		
Attention to 2-3 specific products, markets (e.g. virtual medical diagnostics)	Creation of product development ‘teams’	Recognition as the location for innovation, creative materials
Big Idea #4: Hawaii Bioproducts Initiatives: Renewable Energy & Bio-fuels		
Establish prioritized agenda of market analysis, targets. Form Biofuels Working Group and Neutraceuticals Working Group	Launch Biofuels Investment Corporation to create collection-conversion-delivery fuels system	Reduction of oil-based energy supplies by 25% from converted biofuels.
Fundamental Action #1: The Statewide Workforce Continuum		
Organize Continuum ‘Hot Team’ among key providers	Match occupation training and skills for the initial 1000 positions	Successful realignment of education, training, provider, and end-user networks
Fundamental Action #2: Branding and Positioning Campaign		
Coordinate Road Map data with statewide message campaign	Target 10-12 top communications’ outlets for external messaging	Increase inward investment to Hawaii by 20% and recognition of the State role among site selectors, economic developers
Fundamental Action #3: Statewide Funding Team		
Inventory of top priorities from among above agenda	Funding Team and Campaign launched	Promote Hawaii moving from EPSCOR to New Ranking
Fundamental Action #4: The Hawaii Dialogue		
Implementation of legislative agenda for the commercialization focus	Attraction of industry and entrepreneurial risk-taking new dollars, skills	Completion of \$100 million in startup, growth and mature stages of investment
Enabling Factor: Statewide Collaboratory		
Make permanent the electronic infrastructure created from the Hot Team process. Devise mechanism to encourage principal investigators to share knowledge, incentivize cooperation.	Develop structure and methodology for matching grant management/co-investments, secure funding. Assist with branding and positioning efforts.	Facilitate the formation of lasting partnerships between industry, principal investigators, academia, and government. Position the collaboratory as a clearinghouse for research and intellectual property.

Economic and Societal Impact:

Figure 10 – Hawaii Life Sciences: A Balanced Portfolio of Impact



The Economic and Societal Proposition: Immediate, Near, and Long-Term Impact		
Immediate: (0 - 18 months)	Near-Term: (18 – 36 months)	Long-Term (36+ months)
For every \$100 million in research expenditures, Hawaii should foster five to seven new strategic research alliances across academic institutions, three to five alliances with industry, and/or one new consortia that attracts a global firm or entity to the State	For every \$200 million in research, 3 new companies should be formed in Hawaii to assist in eradicating major diseases and healthcare issues. In turn, plant and medical diagnostics/devices should result in new job creation (2500-4000 new jobs)	For every new company formed, new product developed, and new knowledge created in Hawaii – residents should see a 20-30% reduction in the costs of illness, treatments, and overall general health care. In turn, the portfolio of impact should produce economic benefit of approximately \$4-6 billion in services related to the detection, prevention, and treatment of major diseases caused by infectious, cancer and other health issues.

10.2 – Closing: The Imperative to Implement

A series of specific activities are required for the implementation of the Road Map – including the effective collaboration and coordination among key institutions, organizations, and individuals. The execution of the Road Map elements is an ambitious agenda that exceeds the capacities of any one entity including the Life Science Council. In turn the Council can and should play the lead facilitator and convener of a regional network – setting the table for shared responsibility and roles that divide the agenda into sub-tasks; the executive committee and board of the Council must take the lead in establishing the messages and requests for increased investment in the life sciences as a driver of economic development and benefit to society.

To achieve such a leadership role, the Council must coordinate its membership into teams – Resources, Research and Development, Commercialization. For instance, the overall budget of the Road Map demands a coordinated effort among federal, state, regional, academic, industry, philanthropic interests to fully and consistently fund the programs and projects. While the Council itself will need resources for administrating and servicing the general stakeholder community, the agenda for success in the life sciences demands the Council be the lead advocate for fundraising, collaborating, and promoting the industry sector.

Based on the analysis of competitive scenarios, NES believes that the Hawaii Road Map requires a \$55-70 million investment over the next three years. Such an investment would include the acquisition of key research teams, upgrade of facilities and purchase of vital equipment, creation of an early stage investment fund, incubation and related commercialization programs, and organization of branding and marketing deliverables. These funds would additionally leverage existing programs – matching dollars for increasing federal grants and contracts, increase utilization of small business innovation research grants for proof-of-concept funding, equipment and specialized facilities development, etc.

Finally, an annual report card and performance audit on the entire Road Map should be conducted and presented to stakeholders and the general public. Progress, or the lack thereof in certain categories, needs to be honest, clear and precise about the competitive state of the life sciences in Hawaii. Working in concert with the local media, the Council must inform the public the investment in life sciences is not only worthy of further support but continued expansion because of the economic, scientific and quality of life benefits.

End notes:

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- ⁱ National Science Foundation Science and Engineering State Profiles, 2003, Bureau of Economic Analysis, 2004
- ⁱⁱ New Economy Strategies, LLC
- ⁱⁱⁱ Laboratories of Innovation: State Bioscience Initiatives 2004, Battelle Technology Partnership Practice and SSTI, June 2004
- ^{iv} New Economy Strategies, LLC, The Brookings Institution Center on Urban and Metropolitan Policy, 2002
- ^v State of California Governor's Office, May 2003
- ^{vi} Bureau of Economic Analysis, Regional Economic Accounts, 2004, US Census Bureau
- ^{vii} New Economy Strategies, LLC
- ^{viii} New Economy Strategies, LLC
- ^{ix} "Vital Assets: Federal Investment in Research and Development at the Nation's Universities and Colleges," RAND RaDiUS, 2004, National Science Foundation Science and Engineering State Profiles, 2003
- ^x National Science Foundation Science and Engineering State Profiles, 2003, Bureau of Economic Analysis, 2004
- ^{xi} "Vital Assets: Federal Investment in Research and Development at the Nation's Universities and Colleges," RAND RaDiUS, 2004
- ^{xii} United States Small Business Administration
- ^{xiii} "Vital Assets: Federal Investment in Research and Development at the Nation's Universities and Colleges," RAND RaDiUS, 2004
- ^{xiv} 1790 Analytics, LLC
- ^{xv} PricewaterhouseCoopers MoneyTree
- ^{xvi} US Bureau of Labor Statistics
- ^{xvii} US Bureau of Labor Statistics
- ^{xviii} US Census Bureau, American Community Survey, 2003
- ^{xix} US Department of Commerce Technology Administration and Bureau of Industry and Security, *Critical Technology Assessment of U.S. Industry*, August 2002
- ^{xx} US Department of Labor, Employment & Training Administration
- ^{xxi} National Science Foundation Science and Engineering State Profiles, 2003
- ^{xxii} National Science Foundation Science and Engineering State Profiles, 2003
- ^{xxiii} "Vital Assets: Federal Investment in Research and Development at the Nation's Universities and Colleges," RAND RaDiUS, 2004
- ^{xxiv} US Census Bureau